New York (State) Legislature

NEW YORK

LEGISLATIVE DOCUMENTS

ONE HUNDRED AND FORTY-FOURTH SESSION

1921

VOL. VII — NO. 45

ALBANY
J. B. LYON COMPANY, PRINTERS
1921

Legislative Document (1921) No. 45

STATE OF NEW YORK

REPORT

OF THE

Department of Farms and Markets

INCLUDING REPORTS OF THE

COUNCIL OF FARMS AND MARKETS
DIVISION OF AGRICULTURE
DIVISION OF FOODS AND MARKETS

FOR THE YEAR 1920

ALBANY
J. B. LYON COMPANY, PRINTERS
1922

STATE OF NEW YORK

DEPARTMENT OF FARMS AND MARKETS

ALBANY, *January* 1, 1921.

To the Legislature:

In accordance with the provisions of the statutes relating thereto, I have the honor to transmit herewith Annual Report of the Department of Farms and Markets for the calendar year 1920.

WILLIAM E. DANA,
President, Council of Farms and Markets.

STATE OF NEW YORK
DEPARTMENT OF FARMS AND MARKETS
Agricultural Hall, Albany, N. Y.

COUNCIL OF FARMS AND MARKETS

	Judicial Dist.	Residence
WILLIAM E. DANA, *President*	7	Avon
DATUS CLARK, *Vice President*	4	Peru
C. FRED BOSHART, *Member-at-Large*		Lowville
MAY B. VAN ARSDALE	1	New York City
E. LINCOLN ROCKEFELLER	2	Brooklyn
LEWIS L. MORRELL	3	Kinderhook
FRANK W. HOWE	5	Syracuse
JOHN G. PEMBLETON	6	Owego
WILLIAM F. PRATT	8	Batavia
JOHN Y. GEROW	9	Washingtonville
EDWIN J. O'MALLEY, *Ex-officio*		New York City

GEORGE L. FLANDERS, *Counsel.* HERBERT W. LEVERSEE, *Secretary*

DIVISION OF AGRICULTURE

GEORGE E. HOGUE, *Commissioner*
S. C. SHAVER, *Deputy Commissioner*
WALTER S. GREEN, *Secretary*

Bureau of Accounts............................*Director*, E. P. KERWIN
Bureau of Plant Industry.......................*Director*, G. G. ATWOOD
Bureau of Animal Industry....................*Director*, D. W. MCLAURY
Bureau of State Institution Farms...........*Director*, HARRY B. WINTERS
Bureau of Farm Settlement.........................*Director*, F. J. CARR
Bureau of Dairy Products..............................
Branch Offices: New York, Utica, Cortland, Rochester, and Buffalo.

DIVISION OF FOODS AND MARKETS

DR. EUGENE H. PORTER, *Commissioner*
A. E. BROWN, *Deputy Commissioner*
FREDERIC E. FOSTER, *Secretary*

Bureau of Markets and Storage.................*Director*, H. D. PHILLIPS
Bureau of Cooperative Associations..........*Director*, CHARLES R. WHITE
Bureau of Food Standardization.............*Director*, DR. E. J. WHEELER
Bureau of Food Products...................*Director*, G. W. V. SPELLACY
Bureau of Licenses.............................*Director*, JOSEPH BEAL
Bureau of Weights and Measures............*Director*, WILLIAM T. WHITE
New York Office, 90 West Broadway........*Director*, HERSCHEL H. JONES
Buffalo Office, 1046–1048 Ellicott Square........*Director*, ELISHA FREEMAN

REPORT OF THE COUNCIL OF FARMS AND MARKETS

To the Legislature of the State of New York:

The Council of Farms and Markets respectfully submits to your honorable body its report for the calendar year of 1920. This report contains a brief account of the work of the Council of Farms and Markets in directing the general policies of the Department.

During the year 1920 the Council of Farms and Markets held twelve meetings, for the determination of questions of policy in the administration of the agricultural and marketing laws and the consideration of various problems of agriculture and food distribution during the year. In addition to these general meetings the Council held a hearing on proposed rules and regulations supplementary to Article 4-A of the Farms and Markets Law, relating to cold storage; two conferences to consider problems confronting agricultural development and marketing; and a conference on grading and distribution of the season's crop of apples.

Charles S. Wilson resigned as Commissioner of Agriculture as of date June 30, 1920, and George E. Hogue, Director of the Dairy Bureau of the Department, was appointed to fill the vacancy, effective July 1, 1920.

Seward A. Miller resigned as Counsel for the Department as of date September 15, 1920. George L. Flanders, Counsel for the Division of Agriculture, was appointed to fill the vacancy, effective October 1, 1920.

In connection with the resignation of Commissioner Wilson, the Council adopted the following resolutions:

Resolved, That the Council of Farms and Markets accept the resignation of Charles S. Wilson as Commissioner of Agriculture with profound regret that he finds it impossible, for personal business reasons, further to perform the required duties.

Further Resolved, That the Council of Farms and Markets express its appreciation of the splendid service rendered to the State of New York by Commissioner Wilson during his term of office, and the diligent, efficient, and constructive work which has marked his administration, and especially its appreciation of the cordial cooperation with which Commissioner Wilson has carried out the policies of the Council since its organization.

The following resolution was adopted by the Council in connection with the resignation of Counsel Miller:

Resolved, That the New York State Council of Farms and Markets accept with regret the resignation of Seward A. Miller as Counsel for the Department of Farms and Markets. Mr. Miller's legal training and efficiency, his uniform courtesy, and his admirable qualities as a man, have combined to make him a most satisfactory servant to the State. We wish him every success in his new field of service.

At a meeting of the Council held on June 30, 1920, the following resolutions were adopted unanimously, all members present voting in the affirmative:

WHEREAS, Under the present law the Council of Farms and Markets is helpless to make certain desirable changes in the organization and policy of the Department, and

WHEREAS, The need for such amendments to the present law as will properly enable the Council to increase the efficiency of the Department and ensure the proper performance of the various departmental functions is recognized; therefore, be it

Resolved, That the President of the Council appoint a committee of four, of which he shall be a member, to recommend to the Council on or before October 1, 1920, such changes and amendments to the present law as it may deem necessary to make the work of the Department more effective and to perfect the organization of the Department; and further

Resolved, That such report, when and as approved by the Council, shall form the basis for definite recommendations to the Legislature of 1921 embodying the suggested amendments to the law.

In accordance with the above resolutions, President Dana thereupon appointed Mr. Pratt, Mr. Clark and Mr. Howe to serve with him on such committee.

In the matter of Commissioner George Gordon Battle's report of his investigation of the Department of Farms and Markets, Mr. Pembleton, at a meeting held July 16, 1920, read the following report of the committee thereon, which he submitted for the Council's consideration:

Council of Farms and Markets, Albany, New York:

GENTLEMEN.—Your committee appointed to study the Battle Report on Recommendations, respectfully reports as follows:

First: After careful study of the evidence and exhibits in relation to the work and activities of Dr. Eugene H. Porter, Commissioner of Foods and Markets, and especially in relation to his outside activities, your committee finds no evidence that his management of the Division of Foods and Markets was in any way adversely affected by such activities. There is no evidence nor charge of malfeasance in office against the Commissioner, and the burden of complaint seems to have been based upon his activities as director of the Dairymen's League during the early part of his tenure of office. There appears to have been no neglect of duty on the part of the Commissioner and no evidence that any of his official acts were influenced or colored by his position as director of the Dairymen's League. This position was resigned in the fall of 1918. Your committee believes that the recommendation of Commissioner Battle to the Council advocating the removal of Dr. Eugene H. Porter from office as Commissioner of Foods and Markets is not well founded, is not supported by the evidence and should not be favorably acted upon by this Council.

Second: With relation to the charges of incompetence made against Commissioner Wilson, your committee finds these charges to be based upon mere generalities and to reflect opinions rather

than proof of incompetence. Such charges appear to have been unfounded and certainly not proven and should be disregarded. On the contrary, there is much in the evidence to show the active, extensive, and constructive work of the Division of Agriculture under Commissioner Wilson.

Third: Your committee found no proof of any malfeasance in office on the part of any one of the employees of the Department, and no charges of such malfeasance have been made in the report.

Fourth: Your committee recommends to the careful study of the Council the recommendations of Commissioner Battle with regard to certain changes in the conduct of the Department, without comment upon the merit of such recommendations. This is a matter of opinion which should be decided by each member of the Council in the exercise of his own judgment, and therefore your committee makes no findings nor recommendations in connection therewith.

Respectfully submitted,
J. G. PEMBLETON.

Following discussion, it was moved and seconded that this report be adopted. The motion was carried unanimously, all members present voting in the affirmative.

GENERAL ADMINISTRATIVE FUNCTIONS

On September 14, 1920, a hearing was held by the Council at Syracuse, N. Y., in reference to the proposed rules and regulations supplementary to Article 4-A of the Farms and Markets Law, relating to cold storage. This hearing was held at the request of The New York Poultry and Game Trade Association of New York City, which sought a revision of proposed Rule 3-a in regard to exemptions, and also contended that a supply house is a retailer and hence not within the provisions of the law. After careful consideration of the matter, and upon advice of the Attorney-General, the Council denied the request for such revision and overruled the contention of the Association, adopting the rules as proposed.

In connection with the appointment of Mr. Flanders as Counsel for the Department, the matter of placing all legal work of the Department under direct charge of the Counsel was considered and the following resolution adopted:

Resolved, That the Counsel of the Department of Farms and Markets shall, until further direction, supervise and direct the routine work of the legal service for both divisions of the Department.

In July, 1920, an order of the court granting a review of the findings of the Council in the Karakul Sheep Case was filed with the secretary and individual members, such order being returnable on or before August 13th. The matter was left in the hands of the Counsel of the Department for necessary attention, and at a

meeting of the Council held November 5th, the Counsel was directed to ask the Attorney-General to take an appeal from the decision of Mr. Justice Hinman to the Appellate Division of the Supreme Court.

CHANGES IN MEMBERSHIP

Mr. E. Lincoln Rockefeller was elected by the 1920 Legislature as a member of the Council from the Second Judicial District, to fill the vacancy caused by the death of Mr. James H. Killough.

COUNCIL OF FARMS AND MARKETS,
By W. E. DANA,
President.

ALBANY, N. Y., *April* 11, 1921.

DIVISION OF AGRICULTURE

Under the direction of the Council of Farms and Markets, the enforcement and the carrying out of the provisions of the law pertaining to agriculture are assigned to the various bureaus. The bureaus in the Division are as follows:

Bureau of Dairy Products
Bureau of Animal Industry
Bureau of Plant Industry
Bureau of Farm Settlement
Bureau of Statistics
Bureau of State Institution Farms
Bureau of Accounts
Legal Bureau

Branch offices of the Division of Agriculture are located in New York City, Buffalo, Rochester, Utica, and Cortland. Through these offices, which are under the direction of the Commissioner of Agriculture, the general laws are enforced. The editorial work, preparation and distribution of bulletins of the Division of Agriculture, is in charge of administration and comes under the general supervision of the Commissioner. During 1920, 30,000 bulletins, containing important information for farmers, were distributed. Reports and pamphlets to the number of 10,000 were also distributed. In addition to this, reports and information were sent out for general publication.

The following reports from the bureaus show their activities in 1920.

BUREAU OF DAIRY PRODUCTS

An important function of the Dairy Bureau is the testing of milk and cream to determine the amount of butter fat, and to furnish protection against the sale of milk that is adulterated or that is not up to the standard of butter-fat content required by law. The report of this bureau shows 172,360 tests of milk were made; that 476 samples were taken and forwarded to the department for analysis, in the effort made by this bureau to protect the consumer. The result of this work is shown in reduction to the minimum of adulteration of milk offered for sale.

Protection to the consuming public against adulterated or unclean milk or milk products; the unlawful use of oleomargarine and other butter sub-

stitutes; the protection to farmers in the purchase of concentrated commercial feeding stuffs, commercial fertilizers, and seeds, and in the butter-fat test of their milk and cream, comprise the chief functions of the Bureau of Dairy Products. This work consists in surveillance by the representatives of the department of all plants and places in the state where milk is received from producers for the purpose of manufacture or for reshipping for consumption, and the accurate butter-fat test of samples of producer's milk where test is used for the basis of payment.

Article III of the Agricultural Law, with the exception of sections 55 and 61, the enforcement of which has been assigned to this bureau, relates to butter, cheese, condensed milk, and oleomargarine; the use of cheese brands; protection, care, and handling of milk and cream and feed of cows from which milk is produced and sold to the consumer on the markets of the state; unclean milk receptacles and places of keeping milk; misuse or misappropriation by any person other than the owner of milk cans or bottles; unsanitary conditions in cow stables and dairy establishments; the examining of candidates and the issuance of licenses to test milk and cream for the butter-fat content by the Babcock method; and the mixing of animal fats with milk, cream, or butter.

Under article III there have been 160 advertised examinations held in the different dairy sections of the state. These are usually held once a month and are advertised in the local papers, that any wishing to take the examination may receive due notice. During the past year there have been issued 2,432 certificates for testing milk and cream by the Babcock method, many of which were issued to women.

PREPARATION OF LISTS

Under a recent amendment purchasers of milk or cream are required to prepare a list containing the names and numbers of the producers whose milk or cream has been tested and to place beside each producer's name or number the percentage of fat found to have been contained in the sample of milk or cream delivered by such producer. It is required that such list shall be made with indelible pencil or ink, and shall be filed in the plant or place where such milk or cream is bought or received, and shall be duly signed by the person making the test and preparing such list. It further provides that such person shall place beneath his signature the number of his state license under which he is testing. Such list shall be kept as a record for at least one year and shall be open for examination at all times to the Commissioner of Agriculture or his duly authorized representatives. Upon request of producer he is permitted to examine such record, or such part of such record as contains information concerning samples representing the product delivered by such producer. Further provision is made that such test shall be made only at the plant or place where the product is received. The Commissioner of Agriculture is authorized to permit the removal of such samples for the purpose of testing. Duplicate samples of milk are to be held ten days, cream to be held one day.

Further provision is made that on written request of the producer the purchaser or receiver of milk is required to render daily a written statement of the amount of milk so received.

Another amendment to article III made at the last session of the legislature provides that a product known as "milk and cream" when sold in the markets of this state shall contain at least 10 per cent. fat.

A further amendment requires that skim milk or whey, which are by-products of butter factories, cheese factories, and other dairy plants, if returned, given, sold, or delivered to persons who may thereafter use the same for feeding purposes, shall before being so returned, given, sold, or delivered, be heated to a temperature of 150 degrees Fahrenheit. It requires that no skim milk or whey from such plants shall be fed to domestic animals until after it has been heated as herein provided.

BABCOCK TEST

The enforcement of provisions of the statute covered by article III requires a large amount of work on the part of this bureau.

Under the new amendment it has been found necessary to give instructions in many places relative to the Babcock test work as well as to other provisions of the law. It has been found necessary in some instances to make several visits to the same plant for the purpose of retesting composite samples of milk and comparing same with the test made by the person holding the licenses issued by this department for testing milk or cream. In all cases our agents are required to file a report with this bureau showing result of licensee's test, as well as agent's test, for such consideration and action as may be required. There seems to be little doubt that the amendment relative to Babcock testing will be of great value to the dairymen of the state, especially when it is considered that the butter-fat basis for the purchase of milk has been generally adopted throughout the state as a basis of payment.

The records of this bureau show that during the year approximately 172,360 lots of milk have been tested, and 476 official samples of milk have been taken and forwarded to the chemist for analysis. This indicates a close surveillance by the agents of this department, and that the adulteration of milk offered or exposed for sale has been reduced to the minimum, and that the consuming public has been proportionately safeguarded.

A recent census compiled by this department shows that milk and milk products for the year 1919 were valued at approximately $300,000,000. Considering that milk is so essential a food, it will readily be seen that the enforcement of the statute against adulteration is of increasing importance to the consumer.

ADDITIONAL ACTIVITIES

Cheese instructors of this department, who are under direction of this bureau, have given instruction in the manufacture of cheese in New York state. Each year the work is considered valuable, owing to the fact that many factories have to be operated by inexperienced makers.

Samples of the product made from skim milk and vegetable fats have been taken and analyzed by direction of this bureau, and in a number of cases penalties have been paid. The same has been true of milk, cream, and milk and cream mixed.

An unusual amount of investigation and inspection has been done at restaurants, hotels, and boarding houses, and at wholesale and retail stores, in connection with law enforcement in regard to the sale of oleomargarine.

Through its agents the bureau has made during the year a survey of milk and dairy statistics in the state, showing the production and manufacture of milk and dairy products.

EXHIBITS PROVIDED

This bureau was assigned by the Commissioner of Agriculture to the direction of the work of the department in connection with the New York Milk and Child Health Campaign, held in Grand Central Palace, New York City, during the week of May 17, 1920. For making an exhibit provided by chapter 406 of the Laws of 1920, $26,000 was appropriated. In spite of the fact that only ten days were given in which to prepare this exhibit, it was far more extensive than ever before. There are those who feel that this exposition exceeded all expectations in the educational value of the exhibits themselves, as well as in the attendance of many thousands of children and adults who visited the exposition. The department brought to New York City sixteen different exhibits, as follows:

1. A library of milk and agricultural literature.
2. A display of charts showing statistics of dairy products.
3. A display of cattle feeds and grain, showing a decrease in the amount, and an increase in the price.

4. A laboratory, showing the chemical and bacteriological methods for testing milk.
5. A pictorial display of cattle breeds and thoroughbred herds in New York State.
6. A very large exhibit of cheeses of all kinds and qualities manufactured in the state.
7. A display of farm animals, including calves of every age from one month to eighteen months, pigs, chickens, dogs, and cats, contrasting animals milk-fed with those not milk-fed.
8. Large chart and labels, indicating the number of dairy cows in each county of New York State.
9. A certified milk booth with stereopticon displays.
10. Several booths showing different branches of plant industry in New York State.
11. A booth showing farms for sale in New York State.
12. Model of dairy farm, milk factory, railroad transportation, and milk delivery from cow to consumer.
13. A big cheese, weighing between three and four tons.
14. A booth entitled "Fountain of Youth" showing milk and preparations which can be made from milk and its value as a food for young and old.
15. Office and headquarters of the Department of Farms and Markets.
16. An organization series of school contests in the public schools of the city with daily performances in a theatre seating one thousand children.

The above series of exhibits constituted by far the most important feature of the exposition, and gave a display which in magnitude and interest far excelled anything done by the state in recent years.

The work of the bureau under the provisions of article III may be given in the aggregate as follows:

Number of factory inspections	1,333
Number of factories at which Babcock test was being used	883
Number of official samples taken:	
Butter	1
Cheese	27
Blended cream	1
Compound evaporated cream and vegetable fat	1
Cream	7
Evaporated super cream	1
Hebe	1
Milk	476
Milk and cream	1
Condensed milk	5
Evaporated milk	20
Oleomargarine	123
Evidence referred to Legal Bureau on following:	
Inaccurate tests of cream, sec. 33	128
Milk standardization	1
Wrongful use of milk bottles	120
Wrongful use of milk cans	2
Daily statements not given, sec. 33	103
Glassware not state-branded, sec. 33	5
Non-license, sec. 35-a	5
Non-license, sec. 45	2
Sec. 35-a, provisions relative to Babcock test	10
Sec. 45, sanitary conditions	1
Number of licenses issued under sec. 35-a	2,432
Number of licenses issued under sec. 45	860
Number of examinations held	160
Number of cheese brands issued	416

COMMERCIAL FEEDING STUFFS

Article VII of the Agricultural Law defines concentrated commercial feeding stuffs and provides for certain statements as to contents and analysis to be attached to packages, and that further statement be filed with the Commissioner of Agriculture. It further provides that the Commissioner of Agriculture take samples for analysis; that analyses be made by the Director

of the Experiment Station and that license fee be paid for each and every brand.

The number of certificates issued, samples collected and number on which evidence was referred to the legal bureau, and amounts paid in license fees are shown in the following table:

Number of feeding stuff samples collected	1,372
Number of feeding stuff samples on which evidence was referred to legal bureau	258
Number of feeding stuff certificates issued	1,254
Amount paid in license fees	$31,350

During the year there has been prepared and forwarded to the director of the New York Agricultural Experiment Station for publication in bulletin form information relative to the samples collected during the past year.

The following table gives the number of certificates issued for the sale of concentrated commercial feeding stuffs since 1904:

Year	Certificates	Year	Certificates
1904	17	1913	574
1905	193	1914	743
1906	280	1915	854
1907	300	1916	1,041
1908	351	1917	1,050
1909	430	1918	1,137
1910	458	1919	1,132
1911	486	1920	1,254
1912	514		

Important amendments were made to Article VII of the Agricultural Law prohibiting the sale of certain compounded feeds containing peanut shells, peanut hulls, rice hulls, rice chaff, rice straw, humus, peat, sphagnum moss, coffee hulls, chaff, sawdust, sand, ground corn cobs except in corn and corn meal unmixed with other materials, or ground cocoanut shells, or any substances injurious to the health of animals or having no feeding value. Amendments also provided for the classification of roughages, and for additional protection of importance to purchasers of such feeding stuffs.

CONSTITUENT PERCENTAGES

Article IX of the Agricultural Law covers the sale and analysis of commercial fertilizer, and provides that there shall be affixed on the outside of each and every package containing commercial fertilizer or material to be used as a fertilizer, a plainly printed statement which shall certify the name, brand, or trade mark; the net weight; the name and principal address of the manufacturer; and the minimum percentage of each constituent which may be contained therein as indicated in each subdivision thereof.

This article provides for the payment of $20 license fee for each and every brand of commercial fertilizer offered or exposed for sale in the state; also that a sample shall be taken at least once each year by the Commissioner of Agriculture and forwarded to New York Agricultural Experiment Station for analysis.

The following table is a summary of the work performed under Article IX:

Number of samples of commercial fertilizer collected	781
Number of samples of commercial fertiliser on which evidence was referred to the legal bureau	71
Number of fertiliser certificates issued	1,167
Amount collected in license fees	$23,340

Article X covers turpentine and linseed oil. The enforcement of this article is for the purpose of protecting the purchaser against adulteration of these products. Under this article, 53 samples of turpentine and 34 samples of linseed oil were taken and analyzed, and evidence relative thereto referred to the Legal Bureau.

Article XV of the Agricultural Law defines agricultural seed, and provides regulations in regard to their sale. This law was amended by Chapter 90 of the Laws of 1920, which took effect July 1, 1920. This was practically a new seed law, providing for the purity and germination of seeds when sold within this state. It is in the interest of production and is of advantage to purchasers of such seed.

During the year there were 254 samples of agricultural seed collected, evidence relative to 27 of which was referred to the legal bureau.

BUREAU OF PLANT INDUSTRY

Insect pests and fungous diseases cost immense sums annually through their inroads on fruits, grains and vegetables, and injury to trees. The Bureau of Plant Industry is constantly on the alert in its efforts to control and eliminate these pests and diseases, and through its agents and inspectors has the whole state under surveillance so that any new outbreak may be apprehended. This bureau has supervision of nurseries in the state and has under inspection 8,000 acres planted with nursery stock.

Control of dangerously injurious insects and plant diseases in 1920 was carried on without material change in method but some interesting developments may be noted.

NURSERY INSPECTION

Inspection of the places where nursery stock, trees, etc., were grown in 1920 indicates changes resulting from conditions following the war, as shown in the table of comparisons:

	1915	1920
Number of certificates issued	940	600
Number of acres	11,911	8,300
Number of vineyard certificates	32	28
Number of fruit trees in nurseries	54,483,740	15,509,062
Number of ornamental trees and seedlings	20,378,437	13,043,119
Number of shrubs and plants	9,129,665	10,560,955
Number of grapevines	28,004,347	9,999,722

SHIPMENT INSPECTION

Approximately three thousand shipments into the state of nursery trees and plants for orchard and ornamental plantings were made and were found free from deleterious insect pests. The number of shipments in 1915 was 4,347, showing a falling off on account of the war.

Importations of nursery stock from abroad fell to 120 shipments from 1,749 in 1915. This change resulted mostly from the effects of federal quarantines which prohibited all but very limited importations from all foreign countries.

INSECTICIDES AND FUNGICIDES

One hundred and fifty-three samples were collected on the open market and sent to New York Agricultural Experiment Station for analysis as provided by the Agricultural Law.

EUROPEAN CORN BORER

The quarantines placed by the federal government to protect the corn-growing states were embodied in state quarantines to protect the remainder of New York from spread of the pest. These quarantines were enforced in co-operation with Federal Horticultural Board, in the two infested sections of New York State, which included the area found infested near Buffalo and westerly, in the fall of 1919. Evidence was accumulated which indicated the potential damage to be expected from the spread and ravages of this newly introduced pest.

BROOD DISEASES OF BEES

Appropriations by the 1920 Legislature of $5,000 permitted the employment of fifteen special inspectors to assist the two regular inspectors in regulating and cleaning up the two contagious diseases of bees which had, owing to favorable conditions, been recently increasing in some of the counties of the state.

While the work was not completed, much progress was made. Of over 2,100 apiaries carefully inspected, 750 were found infected by disease. About 10 per cent of the 40,000 colonies inspected were diseased. Four hundred apiaries had European foul brood. Two hundred and fifty apiaries had American foul brood.

The apiary law was amended in 1920 and provided certification requirements for moving or shipping bees and also required assessors of the several townships to report to the department the names and addresses of beekeepers under their jurisdiction. This measure has proved of great advantage to inspectors in locating colonies of bees.

NEW YORK STATE APPLE GRADING LAW

From July, 1919, to July, 1920, 3,136 inspections of shipments were made and formally reported; 2,959 inspections were made and reported between July, 1920, and January 1, 1921. Of these

5,539 were up to standard
451 were discontinued, after investigation
105 violations were referred to counsel for action.

CO-OPERATION AND EXHIBITS

During the season of 1920, public demonstrations of the Apple Grading Law were made in co-operation with the farm bureaus, agricultural societies and fairs, as follows:

Cayuga County Fair, at Moravia
Columbia County Fair
Dutchess County Fair and three other demonstrations in the county
Greene County, three days in orchards
Monroe County, six demonstrations
Oswego County, two days in orchards
Orleans County, one day at Albion
Ontario County, one day at Hall
Wayne County Fair, Palmyra
Westchester County, one day with farm bureau orchard meeting.

Other Exhibits

European corn borer, one week at Hamburg Fair, Erie County.

Bureau exhibit of specimens of deleterious insects and diseases, including such as affect apples, corn borer, etc., at the Dairy Show in New York City.

Same also repeated at the State Fair in Syracuse, to which was added a demonstration of the Apple Grading Law.

Same also repeated at Poughkeepsie, at Fruit Growers' meeting in February, and at Rochester.

INSECTS AND DISEASES

Some European insects menace New York State to such an extent that it is never known what a season may bring forth in the form of depredations.

Gipsy moth.— The gipsy moth, an insect that has cost the New England States over fifteen millions of dollars, and for methods of suppression requires contributions in excess of one million dollars annually, has appeared in natural spread like an advancing army to within twenty miles of the eastern border of the state of New York in Vermont.

In the fall of this year the gipsy moth was discovered in central New Jersey and now infests an area of about one thousand square miles. It is reasonable to believe that, from these large areas infested with gipsy moths, sections of the state of New York may at any time become infested, either by the natural spread or by means of transportation. This is a problem and a menace that is appreciated by few people outside of the infested areas. Its importance is therefore specially emphasized.

Brown-tail moth.— Following the appearance of the gipsy moth in New England, the brown-tail moth appeared in Massachusetts and spread rapidly over the New England states. Owing to its destructive and poisonous nature it caused much alarm. Because of some reasons not wholly accounted for, the spread ceased and most of the insects disappeared, but they are rising again in importance; enough were left over to begin their career of destruction.

European corn borer.— The several circulars issued by the department discussed this problem minutely. It is evident from the way in which this newly introduced corn pest from Europe is thriving under conditions in this country that, notwithstanding all efforts at extermination, the time will shortly come when restrictive measures other than quarantines to keep the insect within its borders will have to be abandoned.

Recently imported insects

Other insects that should continue under the surveillance of the inspectors of the bureau are the following:

The Oriental peach moth, infesting increasing territory down the lower Hudson. This insect is important, as it not only injures the trees but is very destructive to fruit wherever it becomes established.

Evetria buoliana, in eastern New York, is found injurious to pine trees.

Aporia crataegi, having a life history similar to the brown-tail moth, but which theoretically may not become as important.

The cherry ermine moth, which appeared in 1916, continues to be a danger in the growing of nursery stock if not controlled by proper spraying.

The apple and thorn skeletonizer, an insect which destroys the foliage of trees, as indicated by its name, is now infesting two counties.

The Japanese beetle, which obtained a foothold in parts of New Jersey and Pennsylvania, is proving very destructive to most fruit trees, and owing to its active flight is spreading very rapidly from year to year.

The bronze birch borer, which threatens the early destruction of the beautiful cut-leaved birches has appeared over the state.

DELETERIOUS DISEASES

The rapidity and virulence with which fungus and other diseases attack trees and plants and spread to large areas within short periods of time is indicated by the loss of the American sweet chestnut, which has become total in the eastern part of the state, and unfortunately is spreading throughout the chestnut belt of the eastern seaboard. While no remedy for the control of this disease has been discovered, its rapid spread emphasizes the fact that, whenever a new disease appears, it should be placed under immediate quarantine with the hope that it may be kept within reasonable bounds until an approved remedy is discovered.

The blister rust of the pine, which, if permitted to spread, threatens the native white pine and five-leafed species. The elimination of the black currant from the state has undoubtedly partially checked the spread of this disease. Additional efforts should be carried out to perfect methods of control and give to pine and currant growers complete information to carry on such work.

Powdery scab of the potato, an introduced disease, placed under restrictions by government and state quarantines, fortunately proved not a serious disease in potatoes in a climate like New York.

The potato wart disease, which was brought from Europe about the same time, caused much alarm owing to its destructive possibilities. Fortunately

it never became established in the state but recently has appeared in Pennsylvania, and may be taken as a warning that its movement should be watched.

The Mosaic disease of potatoes and cucumbers is under investigation by the Pathologist of this Bureau, who is working out some theories in cooperation with the Long Island Railroad Experiment Station the result of which, it is hoped, may eliminate obscure problems in connection with Mosaic.

The above is a brief statement of conditions relating to comparatively recently introduced insects and diseases, but we have in the state the usual number of difficulties to meet. A proper development of our orchard industry requires that known destructive insects should be eliminated and that the natural spread of fungi should be checked.

BUREAU OF FARM SETTLEMENT

The advantages of New York State as an agricultural state are set forth by the Bureau of Farm Settlement. This bureau advertises New York State farm lands for sale or to rent; points out to prospective purchasers their value and the excellent marketing conditions which prevail; and by peopling farms which have been practically unused brings about an increase in production.

The bureau prepares a list of farms for sale or to rent in New York State with brief descriptions of each farm, which has a wide circulation throughout the country and which is much in demand. Applications for laborers are made to this bureau and suitable, reliable, and efficient farm hands are provided.

The loss of experienced farm labor during the past year was very damaging to New York State farming operations. To overcome as much of this loss as possible the Bureau of Farm Settlement centered much of its efforts in trying to supply this want, and to create a demand for farms in New York by the dissemination of information in regard to its agricultural advantages among immigrants and other prospective farm purchasers.

FARM LABOR

The major portion of the work of supplying farm labor was done from New York City, as this seemed to be the only place where it was possible to recruit any considerable number of hands. Using a policy of rigid selection. only experienced help was sent where such was requested; or, if inexperienced, only such as it was believed would make good on the farm. Valuable assistance was given by the Employment Department of the Industrial Commission, who offered the use of their extensive facilities for securing help, and their cooperation in furthering our work was fully appreciated.

Farm labor applicants to the number of 1,764 have applied to this bureau for positions on farms. A great number of these were inexperienced but willing to go on farms, even if for a short time; part were cared for in camps of seasonal workers. Eight hundred and fourteen (814) laborers such as milkers, truckmen, gardeners, harvest hands, fruit pickers, and packers — 573 of whom were inexperienced or had very little experience, 241 having had experience — were sent to farms in different parts of the state. Through the aid of the county agents 228 men, both experienced and inexperienced, were placed with New York farmers.

FARMS FOR SALE

The distribution of the bulletin "Farms for Sale or Rent in New York" has been greatly extended and it is now widely sought after as a source of reliable agricultural information in regard to the state of New York. Much time and effort was spent in rewriting and reorganizing the information contained in the descriptions and general sections of the publica-

tion so as to have it as reliable and complete as possible. Through its wide circulation a very great increase in correspondence has resulted in regard to farms, crops, markets, seeds, stock, machinery, and in fact almost every question which arises in the course of a successful farming operation. All of these have been answered by this bureau. Often the farms are visited and special recommendations made.

The Bureau of Farm Settlement has assisted a large number of prospective buyers in making intelligent selections of farms that would be best fitted for their individual needs.

Investigations carried on by this bureau show that farm buying in the state is regional — groups of buyers originate from areas closely connected and locate within easy distance of each other in New York. A large number come from the middle western states.

VALUE OF FARMS SOLD

Farm descriptions were published in 1920 to the number of 4,112. Of these 1,003 farms have been sold, at a total value of $5,896,800. This record contains only farms for which the bureau furnished a means of advertising; however, its efforts have resulted in a greater number of sales of which it has no information, because through its advertising many have been induced to come to the state, though they have not bought a listed farm. A detailed list of farms sold, by counties, is given below:

County	No. farms sold	Value	County	No. farms sold	Value
Albany	22	$111,000	Oneida	52	$309,400
Allegany	18	95,800	Onondaga	31	217,000
Broome	26	118,900	Ontario	10	54,100
Cattaraugus	27	150,600	Orange	29	194,300
Cayuga	24	178,500	Orleans	3	23,400
Chautauqua	49	330,400	Oswego	20	95,800
Chemung	8	28,300	Otsego	25	101,100
Chenango	38	148,200	Putnam	4	44,500
Clinton	6	40,500	Rensselaer	19	95,000
Columbia	29	173,600	Rockland	1	12,000
Cortland	22	117,400	St. Lawrence	18	100,600
Delaware	33	177,900	Saratoga	32	142,700
Dutchess	22	128,300	Schenectady	5	17,900
Erie	18	120,000	Schoharie	27	92,600
Essex	9	58,000	Schuyler	18	71,000
Franklin	10	69,200	Seneca	6	62,500
Fulton	8	20,200	Steuben	12	59,800
Genesee	11	134,200	Suffolk	4	41,000
Greene	18	83,200	Sullivan	18	82,700
Hamilton	1	2,700	Tioga	20	69,800
Herkimer	9	75,500	Tompkins	29	105,400
Jefferson	20	160,000	Ulster	24	139,700
Lewis	22	100,100	Warren	11	28,600
Livingston	15	116,600	Washington	18	57,200
Madison	25	139,800	Wayne	12	101,000
Monroe	11	159,700	Westchester	4	45,500
Montgomery	9	40,400	Wyoming	13	90,800
Niagara	18	163,000	Yates	10	69,300

There were sold by a New York city representative, 10 farms with a value of $56,500.

In addition to the above 14 farms not described in the 1920 bulletin, were sold, with a value of $63,100.

Total number of farms sold	1,027
Total value of farms sold	$6,016,400

Fully 75 per cent of all farms sold in this state can be traced directly to our farm bulletin. Approximately 60 per cent of these sales were to western farmers who bring improved farm machinery and tools and till the soil far better than the average New York State farmer, thereby largely increasing the products of the state.

Several times a week during the year we visited the consular agents, steamship agencies, and different immigration centers in order to obtain an idea of the nature and classification of our aliens. The data and information in general are as follows: There arrived at the port of New York during the year 1920 up to and including December 29, 404,346. Of this number 190,896 were females and 74,370 were under sixteen years of age; 136,920 remained in New York City. Approximately 35,000 of these had had some training in European agriculture and the largest part of them were bound for their friends in the western states. Less than 1 per cent of those who remained in New York City could be called skilled in farming operations.

Classification	Arrived	Remained in New York City
Italians (who make up the largest part coming)	93,200	37,430
Poles	48,460	27,380
Jews	75,665	44,076
Spaniards	28,176	11,945
Orientals (so-called Asiatic subjects)	21,285	9,145
Hungarians	18,815	7,474
Slavonians (either Czecho-Slovaks or Jugo-Slovaks)	18,255	9,145
Roumanians	20,950	9,500
Greeks	20,189	8,970
Scandinavians	13,180	2,092
Other nationalities*	46,171	11,773

* England, France, Portugal, Germany, Belgium, Baltic provinces and Balkan states, Hindustan and West India.

IMMIGRATION

There have departed from the port of New York during the year 1920 up to and including December 20, 189,650 persons classed as immigrants, though quite a number are citizens or declarants who obtained passports through the Department of State, Washington, D. C. Of this number 24,800 were females and 3,714 were children under 16 years of age. A large number of these people had accumulated large sums of money during the war by employment in various mercantile and industrial occupations and wished to return to their native homes to aid in reconstruction. Because of very unfavorable conditions, however, many are desirous of returning to the United States and they offer an important field for the work of farm settlement.

After a thorough study of the questions of immigration and emigration it is apparent that the proper time to promote farm settlement work is not at the time of entrance to the country but at a period considerably later. When the immigrant arrives in this country he is without money; his destination is already fixed and he is suspicious of a stranger who tries to change it. After being in this country for some time he has usually accumulated some capital; has been affected somewhat by American ideas and principles; and knows more of the country, its language, and business adaptability. In the city of New York there are located a very large number of societies and organization made up of foreign-born peoples who are banded together either for mutual aid or because of mother country ties. It is at these places that the former immigrants spend their spare time or await passage out of the country. This is the point to begin the farm settlement work, as the delay in securing ocean transportation and other resulting delays make them very impatient; they can then easily be induced to stay here, and the placing of New York State farms in a favorable light should result in many becoming New York State farmers.

BUREAU OF ANIMAL INDUSTRY

The eradication of bovine tuberculosis is in the interest of public health. The work of the Bureau of Animal Industry for a clean milk supply and clean herds by testing and elimination of tubercular cattle constitutes a safeguard against disease.

The activities of the Bureau of Animal Industry have their foundation in those provisions of statute pertaining to the following:

1. Infectious and communicable diseases of domestic animals and shipping, slaughtering, and selling of veal for food — Chapter 311, Laws of 1919, as amended.
2. The licensing of stallions and breeding of horses — Chapter 322, Laws of 1916.
3. The licensing of dogs and protection of domestic animals therefrom — Chapter 767, Laws of 1920, as amended.
4. Protecting the breeding of pure-bred stock — Section 321, Chapter 114, Laws of 1918.

Preliminary to the information hereinafter presented — attention is directed to the two-fold function of this Bureau, namely *Animal Husbandry* and *Animal Disease Eradication*.

ANIMAL HUSBANDRY

The prevailing enormous demand for New York State cattle for foundation herds in other states and foreign countries, denotes the present satisfactory condition of the live-stock industry in the Empire State. This condition is in striking contrast to the situation existing some four or five years ago when many of our sister states were maintaining against New York State live stock, regulations detrimental to our animal industry.

The increased number and value of the pure-bred live stock in our state, has proportionately added to the exacting duties and responsibilities of this Bureau, to the end that the work of live stock sanitation might be effectively performed and every known scientific agency employed which would tend to safeguard against disease and any condition damaging to this industry. During this year the state is fortunate in having experienced no extensive outbreak of acute infectious disease menacing the live stock in a community.

Remarkable progress has been made in bovine tuberculosis control and eradication under the Accredited Herd Plan as carried on in cooperation with the Federal Government. In connection with the accomplishments of the year along these lines, attention is directed to the pronounced sentiment, common to breeders throughout the state, in favor of clean herds, and a consequent clean milk supply; also to the fact that all of the work done has been in response to voluntary requests of the breeders themselves. It will therefore be seen that a most favorable foundation has been laid for the elimination of tuberculosis from the herds of this state.

As herds have necessarily been depleted by the destruction of diseased members, this bureau has been called upon to aid in restocking with animals of a desirable type, tuberculosis-free; and one of the most important features of the accredited herd work is the guarding against re-contamination of those herds from which the known diseased members have been eliminated.

that more young stock, particularly females, be raised; that public live-stock

The Bureau has continued to urge that pure-bred sires replace scrub sires; that more young stock, particularly females, be raised; that public live-stock exhibits be stimulated and encouraged; that the importance of selecting desirable types of cattle, sheep, horses, and swine be recognized; and, in short, to exert its influence in behalf of all activities making for the promotion and up-building of the live stock population of our commonwealth.

Stallion Enrollment

Number of pure-bred stallions enrolled	454
Number of standard bred stallions enrolled	43
Number of non-standard bred stallions enrolled	35
Number of grade stallions enrolled	226
Number of scrub stallions enrolled	186
Total	944

Licensing of Dogs

Number of dogs reported by boards of assessors and police departments of the various towns and cities, outside of Greater New York	258,793
Number reported as licensed:	
Dogs	217,970
Kennels	135
Total amount collected for fees in licensing of dogs	$464,284 04
Amount realized from the sale, and fees for redeeming, of dogs seized because not licensed	3,742 25
Total	$468,026 29
Disposition of these funds was as follows:	
Retained by cities for police pension fund	$25,734 96
Sent to State Treasurer	329,379 35
Sent to county treasurers by town and city clerks	112,911 98

During this period, 1941 claims were passed upon for payment amounting to $125,022.21 as damages alleged to have been done by dogs to domestic animals and fowls.

ANIMAL DISEASE ERADICATION

So rapid has been the growth of the accredited herd work in response to the demand of the breeders that it has been impossible to mark its progress in absolute figures with the small amount of time that could be devoted to the compiling of statistics.

The intradermic method of testing for tuberculosis, adopted in this state in the case of first tests of herds in counties carrying on "free area work" is largely responsible for the pronounced increase in the number of cattle examined this past fiscal year as against corresponding figures for the preceding year when approximately 24,000 animals were examined.

Otsego, Essex, Cattaraugus, Chautauqua, and Allegany counties are doing free area work. This means that these counties have resolved to test every herd therein and remove the diseased animals; and to accomplish this result in the least possible time some of them are hiring a county veterinarian to devote his entire time to this work.

Frequent conferences have been held between the various mutually interested agencies engaged in furthering this campaign.

In the interest of safeguarding public health and from the standpoint of economy, the necessity of eradicating bovine tuberculosis has been recognized. During the past year the accredited herd plan has been unanimously approved as of practical value to the live stock industry.

Approximate number of cattle examined for tuberculosis (privately and officially)	67,500
Approximate number rejected as tuberculous	8,050
Per cent rejected (approximately)	12
Number officially condemned by the state	6,465
Number of localized cases	5,378
Number of generalized cases	642
Number of "No lesions" cases	445
Total appraisal value	$1,213,950 00
Average appraisal value	$189 00
Total indemnity	$506,857 94
Average indemnity	$78 00
Number of herds fully accredited	48
Number of herds which have passed one successful test	243
Approximate number herds under State and Federal supervision	1,000

GLANDERS

Approximate number horses examined for glanders in Greater New York City and vicinity	8,220
Number condemned, appraised and slaughtered	125
Total appraised value	$11,342 50
Total indemnity	9,574 25
Average indemnity	76 00

HOG CHOLERA

Number outbreaks investigated	31
Number deaths recorded in connection with these outbreaks	858

These cases occurred in the following counties: Allegany, Bronx, Chautauqua, Delaware, Erie, Kings, Livingston, Monroe, Nassau, Niagara, Ontario, Orange, Orleans, Otsego, Putnam, Saratoga, Schuyler, Sullivan, Suffolk, Ulster, Westchester, and Yates.

ANTHRAX

Number outbreaks investigated	13
Number deaths recorded in connection with these outbreaks	52

These cases occurred in the following counties: Cattaraugus, Clinton, Delaware, Erie, Genesee, Oneida, and St. Lawrence.

BLACKLEG

Number outbreaks investigated	6
Number deaths recorded in connection with these outbreaks	19

These cases occurred in the following counties: Herkimer, Oswego, Otsego, St. Lawrence, and Sullivan.

SEPTICAEMIA HAEMORRHAGICA

Number outbreaks investigated	16
Number deaths recorded in connection therewith	400

These cases occurred in the following counties: Bronx, Cattaraugus, Chautauqua, Cortland, Delaware, Erie, Franklin, Jefferson, Oneida, Ontario, Putnam, Suffolk, Wayne, and Westchester.

RABIES

Investigations were made by this department relative to rabies in the following counties: Cattaraugus, Erie, Herkimer, Monroe, Montgomery, Niagara, Orange, Orleans, Rensselaer, Rockland, Westchester, and Wyoming. It was found necessary to quarantine geographical areas in Cattaraugus, Monroe, Montgomery, Orleans, Rockland, Westchester, and Wyoming counties. In connection with these outbreaks 67 deaths from rabies in domestic animals other than dogs, are recorded.

MANGE

Investigations for mange in cattle have been made in Cortland, Delaware, Herkimer, Oswego, and Wyoming counties. It was found necessary to quarantine several herds.

SWAMP FEVER

Approximately 75 cases of this disease in St. Lawrence County have been reported and investigated by this office.

VEAL INSPECTION

Number of seizures	867

These consisted of 48 live calves, 785 carcasses, and 34 parts of carcasses.

NOTE.—All statistics herein set forth are for the fiscal year July 1, 1919, to June 30, 1920.

BUREAU OF STATE INSTITUTION FARMS

The Bureau of State Institution Farms has charge of the 42 state-owned farms connected with 37 state institutions. These farms not only provide healthful occupation for patients in the institutions and provide fresh farm products for the consumption of the inmates, but are also models for the guidance of farmers who seek information with regard to advanced farming methods.

The chief work of the Bureau of State Institution Farms is directing the management of the 42 state-owned farms connected with the 37 state institutions and institution sites, as provided by Article 2, Section 12, of the Agricultural Law.

Representatives of this Bureau have visited these farms and the Bureau has made recommendations in regard to their management, the one idea in

mind being to improve and develop the farms to the greatest extent and to produce the most food possible toward the maintenance of the inmates of the various institutions and thus reduce the per capita cost.

The purpose of the farms is two-fold: to provide a variety of healthful work fitted to the patients in various degrees of physical and mental capacity, and to provide fresh farm products at a reasonable price. During the year ending December 31, 1920, these farms produced farm products to the value of $1,588,654. The average daily population of these institutions for the year 1920 was 60,240.

During the year ending December 31, 1920, the total production of milk on state institution farms was 5,507,636 quarts. Pork weighing 738,375 pounds was produced, and 118,340 bushels of potatoes were raised during this period.

FARM ACREAGE, 35,024 ACRES

The following is a list of state institutions, having farm land, together with farm acreage and population:

State Institution	Population	Farm Acreage
	238	92.67
	1,266	220
	175	60.7
	851	375.5
	1,099	482.22
Hills..	354	195 5
	3,135	1,363
	1,303	220
	2,504	183
	6,019	994
	480	998
	635	134
	1,128	13,078
	923	421
	1,446	683.81
	448	171
Industry..	901	1,432
	220	100
	4,904	834.61
	2,433	543
h	210	312
	1,107	103.44
	2,603	1,219.25
	1,480	5
d.	211	175
	4,006	893.58
ndalls Island, New	781	37.5
cipient Pulmonary	399	516
	1,900	269 39
	2,302	594.83
	1,684	1,898.54
ise	714	274
	967	2,078.85
	1,953	1,402
s State School for ncluded with that		
nd Deformed Chil-	248	98 50
	2,851	1,217
		618
	6,319	245
		490
Totals	60,240	35,024.79

These farms are well scattered over the entire state. They vary greatly in fertility and general condition of soil, and some are better adapted to one particular crop than to another. The recent law allowing the exchange of farm products between institutions has proved to be very beneficial, and allows an institution having a surplus of some particular farm product to exchange it with another institution in need of such products and having a surplus of other goods.

The system of farm accounting as outlined by the State Comptroller is proving very satisfactory, and being uniform for all institutions, provides for comparison of the efficiency of each farm. These reports are proving a great help in pointing out the places where improvements can be made and expenses cut down.

COUNTY ALMSHOUSE FARMS

In accordance with Article 2, Section 12-A, of the Agricultural Law, this Bureau has caused an inspection of the various almshouse farms to be made. Copies of the reports of the inspectors and the recommendations of the Commissioner of Agriculture in regard to the management of the farms have been sent to the boards of supervisors in the counties in which inspection has been made. This work has a beneficial effect upon the county farms, in that those in charge of the farms see that the state is interested in the work they are doing and is willing to give them all the assistance possible. A great improvement in the management of many of these farms has been made during the past year.

STATE DITCHING MACHINES

This Bureau has had charge of the thirteen state-owned ditching machines, which were turned over to this Department November 1, 1919, when the Bureau of Production was abolished. These ditching machines have been operated in the various counties of the state under the management of the farm bureau associations of the counties in which the ditchers were located. One mechanic has been employed during the entire year and has helped in keeping the ditchers in working order.

EXTENSION WORK

The extension fund has been placed in charge of this Bureau, and in this connection stereomotographs were operated at twenty county fairs and at several agricultural meetings. At these places slides showing the agricultural advantages of New York State and slides showing the value of milk as a food, especially for children, were used.

At the State Fair the Director of this Bureau was superintendent of the state institutions' exhibits. He also directed the allotment of spaces to the different state departments, and apportioned the $5,000 allotment among the various departments.

The Bureau of State Institution Farms put on a cow-judging contest quite similar to the one held the previous year, and yet differing in that the cows exhibited were all from the same herd and were sired by the same herd bull. The results of this contest were similar to the guessing contest of 1918 and brought out the fact that it is very important for the farmer to weigh his milk and keep daily records of each cow if he is to know whether each individual cow is profitable or not. This Bureau has distributed free of charge to all institutions and farm bureau associations and dairy farms of New York State, milk record sheets especially prepared for keeping such records.

To promote interest in the sheep industry in this state, an exhibit attracting much attention at the State Fair was prepared by this Bureau. A flock of sheep was exhibited and the entire process of taking the wool from the sheep, washing, carding, spinning it into yarn by the old-style spinning wheel, and weaving it into cloth by means of a hand loom was shown. The cloth thus woven was made into an overcoat and presented to the Lieutenant Governor by the Commissioner of Agriculture.

LEGAL BUREAU

The work of the Legal Bureau consists in advising the commissioners, directors of bureaus, and other persons where necessary, as to the law under which they are operating and as to the many phases of its application to the work provided to be done under the Farms and Markets Law, Agricultural Law, and the General Business Law; in corresponding with and consulting with attorneys who are appointed by the Attorney-General to try

cases under the provisions of such laws and advising, in many instances, with farm bureau heads as to the application of the law and the different phases of the work which farm bureaus are performing; in advising with and instructing agents of the Department as to the methods to be pursued in getting evidence in cases of violations of any of the above laws; and in examining all the evidence submitted by the commissioners or the directors of the different bureaus for purported or possible violations of any of the said laws.

During the calendar year of 1920, from evidence submitted to this Bureau from the Division of Agriculture there was found evidence which it was believed warranted reference to the Attorney-General of 4,548 cases for violations of the provisions of the Agricultural Law, as follows:

	Number of cases	
Milk	352	Article 3
Milk bottles	129	
Oleomargarine	105	
Cream	19	
Pipettes, not state branded	1	
Milk cans	3	
Evaporated milk	12	
Nu Krem	3	
Blended cream	1	
Cheese	2	
Renovated butter	1	
Milk and cream	1	
Mixing skim milk with whole milk and selling the resultant product as milk	1	
In relation to dealing or buying cream of producer	1	
Sour cream	4	
Babcock method of testing	2	
Rabies quarantine	42	Article 5
Bob veal	262	
Tuberculosis quarantine	7	
Quarantine violation (lumpy jaw)	1	
Importation of cattle	1	
Failure to enroll stallion	5	Article 5-A
Non-license of dog	2,985	Article 5-B
Assignment claims	30	
Violation to restrain order	3	
Failure to make monthly report of dog licenses	1	
Failure to remit dog license fees	1	
Failure to obey order of justice of peace	3	
Feeding stuffs	352	Article 7
Fertilizers	94	Article 9
Linseed oil	2	Article 10
Turpentine	17	
Misbranded apples	80	Article 11
Foul brood of bees	1	Article 14
Agricultural seed	24	Article 15
Total	4,548	
Penalties collected		$41,120 26

The report made to this office by the Attorney-General for the said calendar year shows as above that there were collected in penalties from the cases that had been referred to him $41,120.26.

Some of the evidenc submitted to this Bureau was found not to be sufficient to constitute violations of the provisions of the statute. In such instances the papers are sent back to the Bureau from which received with advice to that effect.

There has necessarily been frequent consultations with the Attorney-General's office relative to the principles involved and the facts constituting the violations in cases referred to him, and oftentimes in relation to affidavits submitted to that official subsequent to the reference of the cases which have

a bearing upon the cases or some of the facts in connection therewith. These affidavits sometimes disclose facts or conditions not known at the time of the reference of the cases and require careful consideration before determining whether further action should be taken. When cases are referred by the Attorney-General to local attorneys, correspondence is often necessitated between such attorneys and this Bureau in relation to what the witnesses can testify to and what weight such testimony would have, viewed from a legal standpoint. Considerable time is also taken in notifying the witnesses in the different cases and having them ready for trial; also in corresponding with the defendant, and in some cases with the manufacturer, notifying them that their goods were exposed for sale in violation of the statute. Other work of a minor nature consists in advising with those interested in preparing bills as amendments to the laws, the enforcement of which comes under the surveillance of the Department of Farms and Markets.

NOTE: This report does not contain any statements relative to the work of the Legal Bureau in connection with the Division of Foods and Markets.

BUREAU OF ACCOUNTS

There was expended for personal service and maintenance and operation from appropriations made for the year 1919-1920 the sum of $504,702.05.

The Division of Agriculture disbursed for fixed charges and contributions as required by statute $782,323.73.

There was also expended the sum of $500,050.50 which was not chargeable to this fiscal year, but paid out for indebtedness of prior years from balances on hand July 1, 1919.

The total amount of money received by the Division and forwarded to the State Treasurer by this Bureau was $14,618.89.

During this year the Bureau sent to the State Comptroller on account of the Division of Agriculture 187 schedules of accounts and issued 11,705 checks.

There were audited and prepared for payment the following Division of Agriculture accounts:

Traveling expense accounts	2,073
Maintenance and operation accounts	625
Rabies quarantine accounts	118
Per diem employees, personal service	372
Indemnities — Tuberculosis	813
Indemnities — Glanders	115

The following tables give statements of receipts and expenditures for the Division of Agriculture for the fiscal year 1919-1920:

FINANCIAL REPORT

DIVISION OF AGRICULTURE

STATEMENT OF APPROPRIATIONS AND EXPENDITURES FOR THE FISCAL YEAR JULY 1, 1919–JUNE 30, 1920

Chapter	Title	Appropriated	Total	Expended	Total	Balance June 30, 1920	Total
177–1–1919 644–1–1919	Personal Service:	$322,310 00		$312,631 03		$9,678 97	
165–2–1920	Salaries, temporary	103 21		103 21			
177–1–1919	Veterinarians	15,000 00		15,000 00			
165–2–1920	Veterinarians	1,334 00		1,250 00		84 00	
177–1–1919	Appraisers	750 00		750 00			
177–1–1919	Extension lecturers	7,500 00		5,880 50		1,619 50	
177–1–1919	Inspectors	1,400 00		231 00		1,169 00	
			$348,397 21		$335,845 74		$12,551 47
177–1–1919		$15,000 00		$11,930 64		$3,069 36	
177–1–1919		40,000 00		14,379 98		25,620 02	
177–1–1919		3,000 00		742 57		2,257 43	
177–1–1919		14,000 00		14,000 00			
165–2–1920		2,107 26		1,033 99		1,073 27	
177–1–1919		95,000 00		94,885 51		114 49	
165–2–1920		20,000 00		14,482 26		5,517 74	
177–1–1919		17,000 00		14,416 68		2,583 32	
177–1–1919		3,730 00		2,984 68		745 32	
			209,837 26		168,856 31		40,980 95
177–1–1919	unt directors	$85,000 00		$83,888 30		$1,111 70	
177–1–1919		33,600 00		32,950 00		650 00	
177–1–1919		20,900 00		14,148 96		6,751 04	
177–1–1919		3,000 00		2,957 05		42 95	
177–1–1919		150,000 00		149,980 45		19 55	
165–2–1920		50,000 00		41,517 38		8,482 62	
644–5–1919		57,740 44		12,687 00		45,053 44	
644–5–1919		8,419 54		141 28		8,278 26	
177–5–1919		6,262 75		3,397 28		2,865 47	
177–1–1919		10,000 00		9,100 90		899 10	
165–2–1920	s	250,000 00		250,000 00			
1 1920	fees	241,555 12		241,555 13			
408 1920	position exhibit	26,000 00		20,000 00		6,000 00	
			862,477 86		782,323 73		80,154 13

BALANCES OF APPROPRIATIONS IN FORCE JULY 1, 1919, WITH EXPENDITURES CHARGEABLE TO PRIOR YEARS

Chapter	Title	Balance July 1, 1919	Total	Expended	Total	Balance June 30, 1920	Total
571-1-1918		$2,398 50		$2,288 00		$10 50	
571-1-1918		543 00		75 00		468 00	
571-1-1918		4,962 00		3,091 00		1,871 00	
			$7,903 50		$5,554 00		$2,349 50
571-1-1918		$6,300 29		$2,859 33		$3,440 96	
571-1-1918	rts	19,707 92		18,784 76		923 16	
177-2-1919	rts	33,616 95		33,616 95		....	
571-1-1918		2,091 96		137 50		1,954 46	
571-1-1918		943 93		939 18		4 75	
571-1-1918		260 87		247 21		13 66	
571-2-1918		30 60		30 46		14	
571-1-1918		10,057 02		9,382 25		674 77	
571-1-1918		3,561 10		582 03		2,979 07	
571-1-1918		5 00		5 00		....	
			81,575 64		71,584 67		9,990 97
571-1-1918		$340 36		$25 00		$315 36	
571-1-1918		22,235 88		13,838 60		8,397 28	
571-2-1918		13,807 50		6,853 25		6,954 25	
177-2-1919		40,000 00		39,935 57		64 43	
177-5-1919		3,505 25		315 00		3,190 25	
165-5-1920		20,067 48		15,797 34		4,270 14	
177-5-1919		4,643 00		567 00		4,076 00	
165-5-1920		1,725 62		37 50		1,688 12	
571-2-1918		538 75		528 37		10 38	
644-2-1919		4,000 00		3,997 74		2 26	
177-2-1919	e	2,074 40		2,074 40		....	
227 1919	fees	306,951 16		306,951 02		14	
55 1918		129 90		13 20		116 70	
165-5-1920		21,163 85		3,710 75		17,453 10	
177-2-1919		45,948 69		9,707 31		36,241 38	
571-3-1918		10,970 50		4,159 45		6,811 05	
	over	23,962 50		14,399 88		9,562 62	
			532,064 84		422,911 38		99,153 46
	Totals chargeable to years prior to July 1, 1919		$611,543 98		$500,050 05		$111,493 93

RECAPITULATION OF EXPENDITURES

Personal service and maintenance and operation, July 1, 1919–June 30, 1920	$504,702 06
Fixed charges and contributions, July 1, 1919–June 30, 1920	783,323 73
Total expenditures made during 1919–1920 for years prior to July 1, 1919	500,050 05

RECEIPTS, JULY 1, 1919 — JUNE 30, 1920

Wicks Reports	$3.25
Rental of ditching machines	917.05
Stallion enrollment	1,340.50
Apples of New York	705.88
Meats and hides	3,780.95
Dog licenses	7,626.25
Miscellaneous	245.01
Total	$14,618.89

NEW YORK STATE CROP REPORT

Estimates prepared by the Division of Agriculture on production in the state for 1920, of wheat, potatoes, corn, beans, cabbage, buckwheat, barley, rye, oats, hay, onions and fruit; also report on milk production and manufactured dairy products for 1919.

The following shows production as estimated for 1920 of the above commodities in the state:

Commodity	*Production*	*Unit*	*Value*
Winter wheat	7,958,993 bu.	$1.75	$13,928,238
Spring wheat	306,357 "	1.75	536,125
Potatoes	33,522,563 "	1.18	43,096,624
Corn for grain	11,634,492 "	1.16	13,496,010
Beans	1,702,666 "	3.50	5,959,331
Cabbage	597,739 tons	30.78	18,398,406
Buckwheat	4,570,775 bu.	1.40	6,399,085
Barley	2,101,146 "	.99	2,080,134
Rye	1,736,052 "	1.58	2,742,962
Oats	40,881,620 "	.67	27,390,685
Apples (commercial crop)	20,302,361 "	.75	15,226,774
Pears	2,247,266 "	1.05	2,359,629
Peaches	2,265,783 "	2.25	5,098,011
Grapes	110,833 tons	100.00	11,083,300
Onions	3,054,122 bu.	1.317	4,022,278
Hay	5,315,136 tons	23.60	125,437,209
			$296,254,801

The prices from which values were computed are taken from those listed in the monthly bulletins of the United States Department of Agriculture.

Under sections 280 and 281 of the Agricultural Law, it is provided as follows:

The Commissioner of Agriculture may collect and disseminate such information relative to agriculture and agricultural labor within the state as he may deem wise for the purpose of promoting agricultural production within this State.

Supervisors of the different towns and wards in this State shall furnish to the Commissioner of Agriculture, upon request from him, upon blanks to be furnished by the said Commissioner, such information as may be in their possession or may be obtained by them relative to agricultural production and agricultural labor within their respective towns or wards. Such information shall be furnished to said Commissioner within thirty days from the time that it is asked for. Expense incurred by the several supervisors in furnishing such information shall be a town charge to be paid in the manner now provided by law for the payment of services and disbursements for such supervisors.

For various reasons the plan of obtaining statistics through the supervisors of the various towns has not worked out in a satisfactory manner. Although the law is mandatory, experience has shown that some of the supervisors have not been sufficiently interested in gathering and submitting figures so that a report approaching accuracy was available. It was partly as a result of this that the plan of calling on the school children to gather agricultural information was decided on in 1917 and 1918, although it was also assumed that the effect would be to interest the children in agricultural pursuits.

Without doubt, the plan of gathering figures through the school children, directed by their teachers, was an excellent one, since it tended to interest the children in agriculture and the farm. If this plan is repeated, it will be for this reason, since it was with great difficulty that reports were obtained from some sections of the state.

ESTIMATES FOR 1920

Estimates were prepared for 1920 on figures obtained by agents-in-charge in the various districts into which the state is divided. Agents working under the directions of agents-in-charge visited the various producing sections and prepared estimates of the total production. This is practically the first time that figures have been gathered in this way, and if the plan is continued the agents and agents-in-charge will undoubtedly become more proficient in supplying accurate figures on production, as they will have become better acquainted with the producing districts.

In the case of potatoes, the total for the state obtained by the Division of Agriculture was 36,522,563 bushels, while other estimates run as high as 46,000,000 bushels, but it is possible that these were prepared early in the season before potatoes were affected with potato rot.

The report on winter wheat by the Division of Agriculture of a little less than 8,000,000 bushels is a conservative one, other estimates being as high as 10,000,000 bushels.

The Division of Agriculture report shows that New York State kept up to its normal standard in the production of hay, in which it leads, with a total of 5,315,136 tons. The estimate on hay for 1918 was 5,375,000 tons.

The estimate on spring wheat of 306,357 bushels is regarded as low, since the estimate by the United States Bureau of Crop Estimates for 1919 was 750,000 bushels. It is conceded, however, that spring wheat was light in 1920, and in many cases the yield was not more than half of that of the preceding year. The figures on spring wheat were gone over carefully by agents-in-charge of the various districts.

MONROE COUNTY LEADS IN WHEAT

Monroe County leads in winter wheat with an estimate of 972,325 bushels, while St. Lawrence County leads in spring wheat with an estimate of 45,000 bushels.

Livingston County leads in the production of beans, with a total of 300,459 bushels, while Ontario County is second with a total of 224,000 bushels. The total production of beans for the state, as estimated, shows an increase over the 1918 and 1919 production, the figure for 1920 being 1,702,666 bushels. The total production of beans in 1919, in New York State, is given by the United States Bureau of Crop Estimates at 1,450,000 bushels.

Estimates submitted on buckwheat show a total production for 1920 of 4,570,775 bushels, Tioga County leading with 256,338 bushels. Albany County is second with 231,800 bushels. The total of 4,570,775 bushels represents about the normal production of buckwheat in New York State.

The total production of barley in the state is estimated at 2,101,146 bushels, with Onondaga County leading with 162,000 bushels. This is about the normal production of barley.

The total estimate for rye in the state is 1,736,052 bushels, with Columbia County leading with a total of 264,000 bushels, which is about normal.

INCREASE IN OAT CROP

The oat production in the state for 1920 was large. An increase of between 30 and 40 per cent was recorded. The total for 1920 is estimated at 40,881,620 bushels, while in 1919 the total was 29,580,000 bushels. Jefferson County leads in the production of oats, with an estimated total of 3,150,000 bushels. St. Lawrence County comes next with an estimated total of 2,377,600 bushels.

The crop of hay compares favorably with the normal for the state, although it falls somewhat under the total for 1919. The total for the state is estimated at 5,315,136 tons. St. Lawrence County leads with a total of 244,772 tons. Delaware County comes second with a total of 210,600 tons.

PRODUCTION BY COUNTIES OF WINTER WHEAT, SPRING WHEAT, POTATOES AND CORN, YEAR 1920

	Winter wheat, bushels	Spring wheat, bushels	Potatoes, bushels	Corn for grain, bushels
Albany	7,000	1,700	238,000	288,800
Allegany	31,063	6,018	721,697	50,000
Broome	24,420	6,000	795,395	60,000
Cattaraugus	5,100	2,070	352,688	16,850
Cayuga	470,000	3,000	500,000	270,000
Chautauqua	20,000	5,200	1,085,000	95,000
Chemung	57,500	1,200	315,000	100,000
Chenango	8,250	1,000	366,180	91,575
Clinton	500	20,000	1,250,000	140,000
Columbia	6,000	1,800	225,000	536,500
Cortland	11,240	2,000	550,000	30,000
Delaware	600	700	460,800	64,000
Dutchess	30,500	3,600	330,600	668,650
Erie	385,000	14,000	1,260,000	650,000
Essex	400	5,400	220,000	160,000
Franklin	26,568	38,840	1,125,000	75,000
Fulton	1,900	800	297,000	82,740
Genesee	425,000	2,000	625,000	115,000
Greene	17,850	1,440	180,000	231,250
Hamilton	....	....	....	....
Herkimer	1,000	4,000	580,000	45,000
Jefferson	5,500	26,000	656,250	80,000
Lewis	3,151	10,800	371,952	11,100
Livingston	955,192	2,000	863,194	220,691
Madison	40,000	5,000	378,000	50,000
Monroe	972,325	4,000	1,936,721	1,392,139
Montgomery	19,000	3,600	123,500	168,000
Nassau	5,000	300	1,500,000	12,000
Niagara	630,000	8,000	270,000	130,000
Oneida	30,000	17,000	1,265,000	128,000
Onondaga	245,000	8,000	1,200,000	500,000
Ontario	744,000	3,000	1,100,000	265,000
Orange	37,400	1,800	352,000	504,000
Orleans	450,000	2,000	437,000	180,000
Oswego	37,400	2,000	480,000	235,000
Otsego	8,750	15,000	815,000	254,975
Putnam	700	300	52,000	56,000
Rensselaer	5,000	2,000	675,000	360,750
Rockland	1,600	280	70,000	85,140
Steuben	175,294	7,676	1,620,665	119,753
St. Lawrence	3,610	45,000	825,180	260,150
Saratoga	5,400	1,250	660,000	368,000
Schenectady	900	750	116,000	88,800
Schoharie	17,600	4,500	190,300	110,000
Schuyler	108,000	1,500	550,000	73,500
Seneca	500,000	8,500	185,460	280,000
Suffolk	12,000	3,000	3,800,000	12,000
Sullivan	2,100	560	321,000	153,750
Tioga	37,260	3,980	648,750	60,000
Tompkins	160,000	4,500	380,000	130,000
Ulster	40,000	2,550	420,000	332,500
Warren	500	300	280,000	84,000
Washington	6,000	1,500	1,170,000	504,000
Wayne	537,364	1,893	386,102	427,662
Westchester	2,962	1,300	235,000	138,000
Wyoming	325,094	1,500	554,329	29,217
Yates	305,000	2,250	154,800	260,000
Totals	7,958,993	306,357	36,522,563	11,634,492

PRODUCTION BY COUNTIES OF BEANS, CABBAGE, BUCKWHEAT AND BARLEY, YEAR 1920

	Beans, bushels	Cabbage, tons	Buckwheat, bushels	Barley, bushels
Albany	4,950	3,800	231,800	2,160
Allegany	40,737	2,548	100,780	71,955
Broome	2,000	2,000	127,875	13,560
Cattaraugus	4,000	2,700	100,523	16,203
Cayuga	10,000	25,000	125,000	150,000
Chautauqua	2,500	1,800	85,000	9,875
Chemung	28,720	500	133,000	24,990
Chenango	3,200	15,336	74,579	18,240
Clinton	32,200	....	104,800	43,030
Columbia	3,000	150	136,920	2,300
Cortland	1,000	10,000	80,000	15,000
Delaware	2,800	1,200	189,750	5,600
Dutchess	2,600	900	105,000	3,000
Erie	55,000	8,400	80,000	18,000
Essex	5,000	....	22,500	15,000
Franklin	8,195	1,000	30,000	20,000
Fulton	1,680	1,000	43,700	3,875
Genesee	94,800	12,800	30,000	101,500
Greene	3,500	525	103,500	1,200
Hamilton	....	....	....	....
Herkimer	2,800	2,000	45,000	20,500
Jefferson	18,000	....	45,000	45,000
Lewis	1,476	410	21,930	37,800
Livingston	300,459	20,885	38,281	68,197
Madison	10,000	8,800	130,000	75,000
Monroe	43,751	53,750	18,926	96,640
Montgomery	1,300	1,700	82,800	16,200
Nassau	....	40,000	....	....
Niagara	30,000	40,000	25,000	100,000
Oneida	7,800	5,000	37,000	28,640
Onondaga	30,000	40,000	80,000	162,000
Ontario	224,000	58,000	44,000	142,500
Orange	1,950	2,500	33,750	1,900
Orleans	75,000	18,000	15,000	75,000
Oswego	9,500	25,000	68,000	15,000
Otsego	17,680	1,000	195,000	41,440
Putnam	500	250	6,500	600
Rensselaer	2,100	2,600	111,600	2,100
Rockland	1,170	2,100	5,940	250
Steuben	34,861	4,792	156,676	130,000
St. Lawrence	5,000	....	60,480	90,000
Saratoga	8,800	1,250	96,000	2,500
Schenectady	1,200	1,500	66,000	2,000
Schoharie	7,000	400	223,000	17,000
Schuyler	96,000	400	80,000	26,620
Seneca	28,000	18,000	75,800	86,060
Suffolk	5,000	28,000	3,000	1,000
Sullivan	2,470	900	92,400	2,160
Tioga	9,740	4,000	256,338	9,260
Tompkins	26,000	3,500	160,000	65,000
Ulster	7,150	3,200	122,000	3,375
Warren	4,000	200	40,000	350
Washington	5,400	1,350	63,000	4,400
Wayne	134,715	87,249	47,228	69,329
Westchester	500	6,165	550	430
Wyoming	173,462	4,179	85,349	67,407
Yates	70,000	21,000	34,500	60,000
Totals	1,702,666	597,739	4,570,775	2,101,146

PRODUCTION BY COUNTIES OF RYE, OATS, APPLES AND PEARS, YEAR 1920

	Rye, bushels	Oats, bushels	Apples, bushels	Pears, bushels
Albany	105,000	600,000	135,000	16,000
Allegany	10,000	1,052,896	91,170	5,000
Broome	13,000	392,800	150,576	3,000
Cattaraugus	2,080	1,600,885	150,000	2,663
Cayuga	10,000	800,000	160,000	15,500
Chautauqua	2,800	1,105,000	250,000	15,000
Chemung	46,000	326,700	190,000	38,000
Chenango	4,500	539,490	369,612	2,218
Clinton	2,500	607,200	22,000	....
Columbia	264,000	525,000	812,500	80,000
Cortland	1,500	400,000	62,500	1,000
Delaware	3,600	551,000	135,000	625
Dutchess	40,000	665,000	175,000	25,000
Erie	35,000	1,300,000	100,000	54,000
Essex	1,500	315,000	67,300	....
Franklin	15,000	1,200,000	11,000	....
Fulton	3,000	261,800	8,750	150
Genesee	42,000	550,000	200,000	25,000
Greene	41,250	312,000	320,000	51,000
Hamilton	....	....	....	....
Herkimer	1,000	586,500	68,000	....
Jefferson	....	3,150,000	....	....
Lewis	6,100	795,600	27,500	....
Livingston	77,141	849,253	190,392	5,688
Madison	1,300	540,000	125,000	....
Monroe	66,429	1,553,724	3,650,000	675,218
Montgomery	3,200	760,000	75,000	500
Nassau	....	....	....	....
Niagara	25,000	850,000	1,000,000	180,000
Oneida	6,850	1,120,000	200,000	....
Onondaga	8,000	900,000	215,000	234
Ontario	55,620	1,146,000	549,800	105,680
Orange	39,600	245,000	175,000	28,000
Orleans	15,000	550,000	800,000	200,000
Oswego	12,000	885,000	1,312,000	150,000
Otsego	1,950	997,500	162,000	2,900
Putnam	3,200	42,900	45,000	1,050
Rensselaer	225,250	552,500	250,000	31,000
Rockland	9,225	39,600	78,250	2,100
Steuben	60,000	1,684,801	122,421	28,970
St. Lawrence	6,480	2,377,600	3,000	....
Saratoga	52,500	737,200	55,000	1,000
Schenectady	30,400	248,200	30,000	1,500
Schoharie	25,000	544,000	125,000	3,000
Schuyler	37,800	321,600	350,000	32,420
Seneca	10,000	542,500	500,000	33,100
Suffolk	....	60,000	3,000	4,500
Sullivan	27,000	280,000	87,250	1,200
Tioga	21,215	435,100	140,000	4,800
Tompkins	10,500	480,000	200,000	10,000
Ulster	103,500	249,600	350,000	60,000
Warren	2,800	60,000	40,000	....
Washington	40,000	720,000	36,255	600
Wayne	16,262	1,976,436	5,110,000	120,620
Westchester	20,300	17,735	52,497	4,500
Wyoming	11,000	1,000,000	414,588	14,300
Yates	61,700	478,500	350,000	60,380
Total	1,736,052	40,881,620	20,302,361	2,247,266

PRODUCTION BY COUNTIES OF PEACHES, GRAPES, ONIONS AND HAY, YEAR 1920

	Peaches, bushels	Grapes, tons	Onions, bushels	Hay, tons
Albany	4,500	5	4,500	78,000
Allegany	....	....	2,754	92,374
Broome	200	3	500	120,301
Cattaraugus	162	2,880	40,000	140,843
Cayuga	1,000	35	3,500	130,000
Chautauqua	3,500	46,250	58,000	195,000
Chemung	1,800	50	1,000	42,500
Chenango	....	....	....	143,600
Clinton	....	....	....	90,500
Columbia	....	950	5,000	81,000
Cortland	100	2	....	75,000
Delaware	....	....	2,500	210,600
Dutchess	....	62	1,000	110,000
Erie	....	7,000	50,000	140,000
Essex	....	....	....	50,000
Franklin	....	5,000	....	142,200
Fulton	....	....	2,000	40,500
Genesee	....	400	300,000	105,000
Greene	....	8	4,500	81,200
Hamilton	....	....	....	....
Herkimer	....	....	6,500	86,000
Jefferson	....	....	....	180,000
Lewis	....	....	2,952	154,512
Livingston	3,194	19	52,536	96,017
Madison	....	....	333,000	109,800
Monroe	801,168	402	108,154	67,452
Montgomery	....	10	8,000	98,400
Nassau	....	....	....	....
Niagara	900,000	3,000	125,000	120,000
Oneida	....	....	20,000	165,500
Onondaga	790	100	30,000	170,000
Ontario	3,000	8,000	2,000	98,800
Orange	18,000	575	820,000	94,600
Orleans	720,000	2,500	120,000	50,000
Oswego	....	....	75,000	129,000
Otsego	....	....	3,000	187,300
Putnam	900	....	1,000	18,500
Rensselaer	....	1	4,000	75,000
Rockland	....	....	4,000	9,100
Steuben	....	4,500	13,318	115,928
St. Lawrence	....	....	....	244,772
Saratoga	....	....	2,200	71,900
Schenectady	....	....	2,500	31,900
Schoharie	....	....	2,000	90,000
Schuyler	3,000	4,000	500	33,982
Seneca	15,000	3,000	56,000	52,800
Suffolk	18,000	....	....	15,000
Sullivan	....	....	3,500	93,750
Tioga	1,000	1	....	74,000
Tompkins	1,500	50	500	90,000
Ulster	....	3,000	3,000	77,500
Warren	....	....	2,000	32,100
Washington	....	....	4,500	120,000
Wayne	231,360	105	760,338	44,180
Westchester	34,109	3,900	7,815	31,261
Wyoming	700	25	5,955	84,932
Yates	2,800	14,000	600	32,532
Totals	2,265,783	109,933	3,055,122	5,315,136

COMPARISON OF MILK PRODUCTION AND MANUFACTURED DAIRY PRODUCTS IN NEW YORK STATE FOR THE YEARS 1918 AND 1919

	1918*	1919
Numbe[illegible] porting	1,742	1,434
Numbe[illegible] upplying milk	....	84,842
Numbe[illegible]	1,023,094	1,172,727
Milk re[illegible] the year	4,436,982,413 lbs.	5,360,568,948 lbs.
Milk re[illegible] June, 1919	....	629,330,065 lbs.
Milk re[illegible] December, 1919	....	274,917,423 lbs.
Milk re[illegible] April, 1920	....	420,813,040 lbs.
Milk so[illegible] consumption	2,341,401,388 lbs.	2,405,649,249 lbs.
Cream [illegible] n consumption	....	30,588,696 lbs.
Manufactured products:		
Creamery butter	13,897,740 lbs.	14,089,388 lbs.
Whey butter	528,965 lbs.	773,070 lbs.
Whole milk American cheese	37,610,008 lbs.	62,568,629 lbs.
Part skim and whole skim American cheese	3,878,645 lbs.	3,126,731 lbs.
Limburger cheese	4,455,674 lbs.	4,473,824 lbs.
Swiss cheese	1,170,230 lbs.	1,723,284 lbs.
Brick and Munster cheese	1,453,914 lbs.	2,119,122 lbs.
Cottage, pot, bakers and hoop cheese	12,160,255 lbs.	12,242,493 lbs.
Cream and Neufchatel cheese	3,085,617 lbs.	2,625,217 lbs.
Italian and Greek cheese	1,567,892 lbs.	2,950,213 lbs.
All other varieties of cheese	....	2,696,220 lbs.
Condensed milk (whole and skim)	286,618,941 lbs.	426,268,709 lbs.
Evaporated milk (whole and skim)	91,428,870 lbs.	68,388,232 lbs.
Powdered whole milk	2,397,397 lbs.	4,130,423 lbs.
Powdered skim milk	12,075,712 lbs.	14,863,277 lbs.
Powdered cream	534,906 lbs.	525,349 lbs.
Dried casein	2,208,244 lbs.	2,574,825 lbs.
Milk sugar	1,707,225 lbs.	708,255 lbs.

VALUE OF DAIRY PRODUCTS IN 1919

Butter (creamery and whey)	$9,012,221 20
Whole milk American cheese	21,671,328 60
Part skim and full skim American cheese	684,811 92
Limburger cheese	1,565,835 50
Swiss cheese	780,022 80
Brick and Munster cheese	847,648 80
Cottage, pot, bakers and hoop cheese	1,836,373 95
Cream and Neufchatel cheese	787,565 10
Italian and Greek type cheese	1,475,166 50
All other varities of cheese	1,348,114 50
Condensed milk (all kinds)	86,848,816 64
Evaporated milk (all kinds)	9,232,411 32
Powdered milk	1,780,212 32
Powdered skim milk	3,562,049 73
Powdered cream	381,703 84
Whole milk	134,268,795 24
Ice cream	18,655,210 50
Cream	10,951,318 19
Casein	574,965 00
Milk sugar	180,878 85
Total	$306,492,452 50

* Figures for 1918 taken from the final report of the Bureau of Markets, U. S. Department of Agriculture.

DIVISION OF FOODS AND MARKETS

To the Council of Farms and Markets:

I transmit herewith the report of the Division of Foods and Markets for the calendar year ending December 31, 1920, this report summarizing the work of the various bureaus and of the New York and Buffalo branch offices, and briefly outlining the more important features of the problems facing the Division as a whole during the period named.

Important matters of legislation faced the Division at the beginning of the year, and among the measures presented to the Legislature — some of them bearing the endorsement of the Commissioner and your Council — were the cold storage bills, placing private cold storage warehouses under the jurisdiction of the Department, amendments to the Agricultural Law limiting the use of the title "Apple and Cider Vinegar," a bill providing for standard weight loaves of bread, a bill providing for reports of certain cooperative associations to be filed with this Department, and other minor amendments to existing laws which need not be detailed herein.

The first of these bills, namely, the cold storage law amendments, was enacted by the Legislature to take effect October 1; but as no provision for additional inspectors was made, the increased work of inspecting upwards of one hundred private cold storage warehouses has been thrown upon the present force of seven inspectors. This number is no more than adequate to cover efficiently the seventy-seven public cold storage warehouses under the Department's jurisdiction previous to the passage of the amended law.

Rules were adopted by the Council governing foodstuffs in cold storage, upon the recommendation of the Commissioner, these rules taking effect October 29, 1920.

FOOD DISTRIBUTION

Food distribution problems are nation-wide in scope, and one of the constructive steps of the Division during the year was its activity in promoting the organization of a national organization of officials and others interested in the wider aspects of marketing. In February, 1920, the National Association of State Marketing Officials was formed in New York City, of which I had the honor of being elected president. The Division initiated the preparation of a platform dealing with marketing work, which was adopted by the above organization, and which also met with the express approval of the Conference on Agriculture and Marketing, assembled at Syracuse. This platform, the energetic prosecution of which is believed to be essential to more efficient distribution of foodstuffs, is as follows:

1. **Standardization:**
   - (a) Adoption of uniform grades and containers by the various states in close cooperation with the Federal Government.
   - (b) More extensive development of federal and state inspection service for enforcement of grades and standards.
2. **Cooperation:**
   Development by the state marketing bureaus of the following:
   - (a) Organization of producers' cooperative marketing associations for purposes of standardization of farm products and organized marketing.
   - (b) Organization of consumers' cooperative associations for purposes of eliminating unnecessary duplication of service and cost in distribution to consumers.
   - (c) Assistance to cooperative associations in practical problems of marketing and business management.
   - (d) Promotion of uniform advanced legislation for the incorporation of cooperative associations.
3. **Transportation:**
   - (a) Prevention of loss and waste in transit through (1) avoidance of delays; (2) better terminal handling equipment; (3) sufficient rolling stock; (4) improved refrigeration.
   - (b) Development of motor truck transportation.
   - (c) Good roads for farmers.
4. **Regulation of Trade Practices:**
   - (a) Licensing of commission men, cold storage warehouses.
5. **Facilitating Contract Between Producer and Market:**
   - (a) Service by government agencies as medium of contact between producers and markets.
   - (b) Assistance to small producers in finding a market for their products.
6. **Improvement of Terminal Facilities:**
   - (a) Development of definite plans in cooperation with local authorities and transportation agencies for improvement of terminal wholesale markets in large marketing centres and for reduction of expense of terminal handling to the lowest possible minimum.

7. **Market Reporting:**
   (a) Complete and thorough reporting on market prices and conditions daily to state bureaus and the Federal Bureau of Markets in conformance with plans that avoid duplication of effort and make possible furnishing of all information of service to producer or dealer.
   (b) Dissemination of market information in producing areas through newspapers, telegraph and wireless information centers and printed reports.
8. **Research Investigation of Costs of Distribution:**
   (a) Statistical analysis of the various elements in the cost of distribution of farm products from the point of production to the point of consumption.
   (b) Investigations of this type conducted in the different states should be coordinated through the Federal Bureau.
9. **Storage:**
   (a) Adequate storage facilities at shipping and receiving points.
10. **Financing:**
   (a) Extension of credit facilities by existing banking institutions for marketing operations.
   (b) Development of cooperative banks and credit unions.
11. **Education:**
   (a) Of consumer and producer as to benefits accruing to each from carrying out of this program.
   (b) Of middleman and transportation agencies as to purposes of state marketing officials.
   (c) Closer relations with the press in disseminating accurate information on marketing problems.
12. **Legislation:**
   (a) Uniformity among states in so far as conditions will permit.
   (b) Exchange of information as to operation of various laws.

MARKETING

Definite progress during the year was shown by the report of the Bureau of Markets and Storage, to which especial attention is called. Completion of the state-wide shipping point survey, together with the compilation of data concerning existing public markets in the state, were two constructive steps, while the routine work covering transportation, claims and complaints, and the inspection service was carried on efficiently and satisfactorily.

Standards and grades for marketing of potatoes and onions have been tentatively established, and these will, it is believed, be in full effect another season, following hearings to be arranged the coming spring. Establishment of standards and grades for the two commodities named will be a distinct benefit to growers, shippers and consumers of same, and will greatly aid the marketing of these crops in New York State.

A survey was also made of the possibilities of barge canal transportation of farm commodities, and the results of this survey will be of value in the future development of water-borne traffic on our state waterways. Progress of motor truck transportation was also made the subject of a special study, and pamphlets giving information as to the growth and value of this new and important transportation agency were published.

TRANSPORTATION

During March and April railroad transportation conditions became acute on account of the labor troubles and the shortage in rolling stock. The resulting tie-up caused serious delay in the shipping of seeds, fertilizers, farm machinery, and nursery stock. Traffic heads of nine different railroad systems in New York State were called into conference, and embargoes were lifted from the commodities mentioned. In most cases the movement of freight of the character outlined was greatly accelerated. Several hundred complaints were handled through the Bureau of Markets and Storage and the branch offices of the Division, and the railroads interested cooperated promptly after being acquainted with the facts in the conferences mentioned. Enlistment of the railroad officials in this matter was productive of further valuable results in the securing of cars during the harvest season.

COOPERATIVE WORK

Growth of the cooperative marketing movement has been continuous among producers in New York State, who are thoroughly awakened to the need for more efficient methods of marketing their products in order to meet the competition of the larger cooperatively organized agriculture of the West. A detailed account of these activities will be found in the Report of the Bureau of Cooperative Associations, but I would call attention at this time to the special assistance given consumers' cooperative associations during

the past year, a step made possible by provision made by the Legislature for an organizer to give direct assistance to organizations of this character.

Early in the year a survey was made in New York City of cooperative enterprises that were not known even among those in the cooperative movement. Later this preliminary survey was followed by a thorough examination of all cooperative enterprises by agents of the Bureau of Cooperative Associations in connection with the filling out of the annual reports which cooperative corporations are required by law to file with this Department.

One of the most important problems with which the Division has had to deal is that of investigation of private firms who are using the word "cooperative" in the title of their organizations in violation of the State cooperative laws. Working people and other people of small incomes have been greatly exploited in the name of cooperation by such agencies. Seventy-five of them have been investigated in New York City, and action taken to compel them to discontinue the use of the word "cooperative."

A conference of cooperative associations, both of producers and consumers, was called by me in Syracuse, April 30, and May 1, and was attended by upwards of 150 representatives of these organizations. At this gathering, the policy of the Department was made plain, and the entire cooperative movement in New York State received a marked impetus as the result of the exchange of views by individuals and organizations interested.

EDUCATIONAL WORK

MILK SHOW

Various educational activities aimed at acquainting the public with the work of the Division were undertaken during the year, and among these may be mentioned the preparation and operation of an exhibit for the Division of Foods and Markets at the Milk and Child Hygiene Exposition held in Grand Central Palace May 17 to 22. This exhibit showed in panoramic form the various steps in the movement of milk and milk products from farm to city consumer, over which the Department of Farms and Markets has supervision. It was praised by exhibit experts for its artistic unity and effectiveness. Its utility was enhanced by the assistance of volunteer workers from the Consumers' Food Committee and Teachers' College, who explained the story of the exhibit to the crowds.

STATE FAIR EXHIBIT

The exhibit above described, amplified and somewhat rearranged, was presented at the New York State Fair at Syracuse in September, and made a distinct impression. Motion pictures of the Division's work were also shown at Syracuse during the fair. The present equipment of the Division in the way of motion pictures includes one dealing with packing house work, the dairy industry, and New York wholesale markets.

MOTION PICTURE OF WHOLESALE MARKETS

The Division of Foods and Markets determined in the summer of 1920 to produce a motion picture showing conditions in the wholesale food markets in New York city and the channels through which produce must pass between farmer and city consumer. An understanding of these conditions on the part of both farmer and city consumer seemed fundamental to any program for greater economy and efficiency in marketing. Through a film produced by the Community Motion Picture Bureau in August, it is possible for persons in every city and rural community in the State to see just what happens to the hundreds of carloads of produce that come to this market every day. The picture starts with the freight yards in New Jersey and takes one across the Hudson River on the huge floats of freight cars filled with produce. It shows the endless line of longshoremen with hand trucks unloading these cars on the piers. It then shows each operation of the wholesale market, the rush of buyers, the examination, sale, loading, and the distribution by jobbers, until the food reaches the housewife's breakfast table that very morning. The picture further emphasizes the beneficial results of standard grading and packing by the California cooperative farmers' organizations,

and takes you into the wild excitement of bidding at the California fruit auction. Then you are whisked away to the farmers' markets, the largest in the world, where hundreds of farmers come during the night to sell their produce; from there into the jobbing sections, and finally, down into the pushcart district of the East Side.

The film had its first public showing at the Rialto Theatre, at Times Square, New York City, for the week of December 19, and was immediately afterwards started on a schedule of circulation among theatres and schools all over the State. Three copies of it were made, and these were in such demand that by the end of the year all of them had been promised for continuous use nearly six months in advance.

STIMULATING THE MARKETING OF APPLES

Marketing New York State's extraordinarily large crop of apples this fall was a very vital problem, toward the partial solution of which the Division through the Bureau of Markets and Storage and the New York office was able to make a distinct contribution. Before the apple harvest had begun it was obvious that there would be a tremendous surplus in New York State, and at once the endeavor was made to provide new channels of distribution. Through cooperation with the heads of municipalities and by means of conferences with growers, shippers, and others interested, a successful publicity campaign was launched, with "Eat more New York State apples" as a popular slogan. The publicity thus obtained was valuable, and backed by local sales of apples in New York and other cities, the movement may be said to have had a widespread and most beneficial effect, even though thousands of barrels of apples went to waste in orchards up-state because of low prices and other causes incident to inefficient distribution methods.

This campaign showed not only the value of proper packing and grading of New York State apples, but also the possibilities of greater sales through the use of smaller containers adapted to the needs of chain stores and other retailers who have not heretofore handled apples. Attention is called to the reports of the Bureau of Markets and Storage and the New York office covering these points. A special pamphlet in color and appropriate apple tags were prepared by the Division for use among school children and at public gatherings, in order to stimulate apple consumption.

KINGSTON MILK SURVEY

In June, 1920, investigation was requested by the Chamber of Commerce of Kingston of the cost of milk distribution in that city, and a thorough survey of the various items entering into the service given consumers was made and conclusions were presented, which were discussed at a public hearing July 20, 1920, conducted by the Commissioner and the Counsel. The data thus collected was turned over to the Chamber of Commerce, which declared the report to be exceedingly valuable, and that it would be the subject of constructive action in the taking up of changes suggested in the system of milk distribution in Kingston. The complete report was published in the November bulletin.

As the result of complaints from the Troy Market Gardeners' association concerning an alleged boycott of their market at Watervliet by the wholesale dealers of Troy, a preliminary investigation of the matter was made and two hearings were held by me. The evidence collected was submitted to the Attorney-General.

FOOD STANDARIZATION

During the year marked strides were made in the enforcement of the pure food laws, and a series of definitions aimed to give more thorough interpretation to the statutes were presented to the Council by the Commissioner, and adopted, same being published in the November issue of the bulletin. These definitions constitute a valuable constructive step, being designed to assist manufacturers of food products in complying with the laws in regard to content and labeling of their products. During the year special emphasis has

been placed on the prosecution of adulterated beverages, baking powders, bread, honey, egg substitutes, vinegar, and other commodities, and the work of the chemical laboratory is presented in detail in the accompanying report.

Representatives of the baking powder manufacturers of the country were called in conference during February, at which time a definition and standard for baking powder were presented, such definition and standard being finally accepted and now in force. On April 7, a conference was held with manufacturers of dried fruit, to take up the question as to the percentage of moisture and sulphate dioxide permissible in such products. Minutes of both conferences mentioned above are presented herewith.

More than 12,220 store inspections were made by the Bureau of Food Products, which submitted a total of 2,553 samples to the laboratories for analysis. Penalties amounting to nearly $1,200 were collected in the prosecution of cases against retail grocers selling cold storage eggs without labeling as such. In addition, vinegar factories in the State were inspected and samples taken of their products during the year.

WEIGHTS AND MEASURES

In August, 1920, one important conference was held in which efforts were made to secure the complete cooperation of all bakers in the State in a plan providing for the standardization of loaves of bread. Complete reference to this gathering and the results obtained will be found in the report of the Bureau of Weights and Measures.

Other conferences during the year took up phases of the work of each of the different Bureaus directly with the interests concerned, and are presented in more detailed form in their reports.

At a conference on agriculture and marketing in Syracuse in September, the work of the Division was presented by the Commissioner and through reports of standing committees of such conference, and considerable impetus was given to the Division's endeavors toward the solution of the more prominent marketing problems and the building up of organized cooperative effort.

The report of the Bureau of Licenses herewith submitted gives the total amount of fees received from the issuance of licenses to milk dealers, commission merchants and cold storage warehouses, and the report of the legal work of the Division gives a summary of the penalties recovered. The financial statement, also attached, is for the fiscal year ending June 30, 1920, as required under the law.

Reports of the branch offices through which the activities of the Division and the various Bureaus are carried on as local conditions demand are also submitted herewith. Market reporting and other functions of these offices are also contained in their respective reports. Under market reporting, it is planned greatly to extend the present service with the cooperation of the United States Bureau of Markets, during the coming year.

During the period from January 1, 1920, to December 31, 1920, Counsel of the Department transmitted to the Attorney-General for the Division of Foods and Markets 242 cases, some of these cases covering a number of violations. During the same period there was collected in penalties and costs by the Attorney-General, on account of cases which the Counsel had sent to his office, the sum of $4,536. Cases submitted were as follows:

Cold Storage	152
Pure Food (Art. 8)	14
Vinegar (Art. 4)	63
Milk License	2
Action on bond	2
Weights and Measures	9
Total	242
Penalties collected	$4,536

EUGENE H. PORTER
Commissioner

BUREAU OF MARKETS AND STORAGE

During the period covered by this report the routine work of the bureau pertaining to the enforcement of the cold storage laws, the compilation and monthly publication of the amounts of foodstuffs held in storage, the investigation of grievances and complaints on the part of shippers and others against transportation companies and dealers, the rendering of assistance in the preparation and submission of claims for loss and damage of shipments, the general supervision of the issuance of the market reports prepared by the New York and Buffalo offices of the Division, the disseminating of information on marketing subjects by means of correspondence and publications, and the holding of hearings and conferences on marketing subjects, was carried on and was extended and amplified in many ways. In addition there were brought to conclusion a number of special investigations and surveys while others are still under way at the close of the period covered by this report.

ENFORCEMENT OF THE COLD STORAGE LAW

The cold storage work of the bureau has four separate phases as follows: Inspection at frequent intervals of all the licensed cold storage warehouses in the state; preparation and submission to counsel of the department of violation cases resulting from such inspections; making of special inspections of unlicensed warehouses which have applied for licenses, together with other special inspections of unlicensed places when such inspection is deemed necessary; and, lastly, compilation and publication of a monthly report concerning the quantity of foodstuffs held in cold storage within the law.

A summary of the various activities of the bureau connected with the enforcement of the cold storage law is given in the following table:

WAREHOUSE INSPECTIONS

Routine inspections of licensed warehouses	1,944
Special inspections of unlicensed warehouses	375
Total warehouse inspections	2,319
Number of violations (in warehouses) reported during 1920:	
Food overtime	94
Marking	24
Illegal transfer	1
Sanitary conditions	2
Total violations reported	121
Number of violations cases continued from previous year	4
Total alleged violations investigated	125
Number of cases submitted to counsel for transmittal to Attorney-General	103
Number of cases investigated and dropped*	22
Number of cases still under investigation	None
Total accounted for	125
Amount of fines collected during year by Attorney-General on warehouse cases submitted	$2,811 79

* Alleged violations found on investigation to be of a minor or technical nature or of a sort where sufficient evidence of violation could not be secured.

SHIPPING POINT SURVEY

One of the important accomplishments of the bureau during the year was the practical completion of the state-wide shipping point survey started last year. All the counties in the state have now been covered by this work except Nassau and a few points in counties on the Hudson River for which the records are not yet complete because of the difficulty in securing data concerning the shipments made by boat. The information concerning these boat shipments will be available at an early date, completing this part of the record. In Nassau County, however, it does not seem possible to complete the work until arrangements can be made to supply the agents of the bureau

doing the work with motor or other transportation, that they may visit the individual farms and secure data as to the amount of produce hauled to market by truck.

As the result of this work the bureau now has available fairly accurate and complete information for the season of 1919 as to the shipments of all important New York State crops, except milk, including quantities shipped from each station, and the names of the shippers. Data as to the names and location of all canning and other factories and concerning motor truck lines are also included in the material available.

TRANSPORTATION MATTERS

In April and May occurred the acute transportation situation resulting from car shortages and the switchmen's strike. The resulting failure of the farmers of the state to receive needed supplies of seeds, fertilizers, and farm machinery bade fair seriously to curtail the food production of the state during the coming season.

In this emergency the bureau, at the direction of Commissioner Porter, went direct to the heads of the various railroads in the state and, after presenting the seriousness of the situation, was able to secure orders on all state roads giving preferential treatment to all shipments of seeds, fertilizers, and farm machinery. Letters were sent to all county agricultural agents notifying them of this preferential and inviting their cooperation in reporting cases of delayed shipments. The bureau immediately became a clearing house through which complaints were presented to the proper railway officials and prompt action secured. As the result of these activities more than 200 complaints were handled, involving almost that number of cars of various products. The cooperation of the railroad officials in all these cases was especially prompt and gratifying.

Later in the year the bureau received a considerable number of requests to trace cars of cooperage stock delayed in transit, as well as a number of similar requests for cars loaded with other products. As the result of the previous experience with the railroads in the matter of seeds and fertilizers and the contact which had thus been established, it was possible to render much assistance along this line. In addition, a total of five specific complaints regarding discrimination in apportioning cars or inadequate freight and express service were received and taken up with the Public Service Commission.

Prior to the beginning of the peach season the agents of the bureau, in cooperation with the agents of the Public Service Commission and the agricultural agents of the New York Central, made estimates of the number of cars needed to move the crop. This information was forwarded through the Public Service Commission to the Interstate Commerce Commission at Washington. Promises were made that sufficient cars would be supplied, but these promises were not kept and a very serious car shortage resulted. The state agencies, in spite of appeals to the Interstate Commerce Commission found themselves helpless to secure relief in the face of the plan by which all the refrigerator cars of the country were pooled and apportioned under the direction of the Interstate Commerce Commission.

CLAIMS AND COMPLAINTS

The majority of the complaints received by the bureau regarding the loss or damage of shipments or failure to make satisfactory returns for produce on the part of wholesale receivers in the markets have to do with shipments sent to either the New York City or the Buffalo market and are referred directly to the offices of the Division in these cities for investigation and handling. During the year, however, six such complaints were handled directly by the Albany office of the bureau.

INSPECTION OF PERISHABLES

During the month the personnel of the Albany office on request made two inspections of perishable products arriving in bad condition and reported their findings to the shipper. The bureau also acted as arbitrator in one dispute concerning a car of tomatoes arriving at Albany in bad condition.

Five requests for inspection of interstate shipments were referred to the proper local offices of the U. S. Bureau of Markets

SPECIAL WORK IN MOVING THE APPLE CROP

Another emergency activity undertaken by the bureau during the year was in connection with the unusually large crop of apples in the state. At the beginning of the season it became apparent that new market outlets must be opened up and the consumption of apples greatly increased if the loss of a very considerable portion of the crop was to be avoided. Accordingly, the bureau enlisted the co-operation of the newspapers of the state in conducting a steady and widespread publicity campaign to stimulate the consumption of apples. Letters were also sent out to the mayors of all cities in the state urging their co-operation in securing local publicity through motion picture theatres and other means, and in conducting special apple sales. Various consumers' organizations were also induced to aid in this publicity campaign and a special pamphlet, "Eat More New York State Apples," was prepared and given wide distribution through these organizations and through schools. As the result of this campaign the demand for apples in the state was considerably increased. In addition, further publicity in trade papers having a national circulation, together with letters sent to market bureaus of other states, resulted in expanding the market for New York State apples outside the state, as instanced by the large number of inquiries received asking for the names of New York apple shippers.

One special feature of the activities of the bureau in aiding the movement of the apple crop was the successful effort made to induce various chain store organizations to buy apples direct from farmers' organizations and to feature special sales of the fruit at low prices. Some stores which had never before handled apples were induced to conduct these sales. This phase of the campaign could have been still further extended had there been in existence in the state more farmers' organizations equipped to furnish well packed and graded apples in the considerable quantities suited to the purchasing needs of these chain store systems. The need for these organizations, especially in the Hudson Valley, and the need for better packing and grading of New York apples, were the two outstanding lessons of the year in this connection.

An incidental part of the apple campaign was a survey conducted in New York City to determine the existing margin between wholesale and retail prices for apples. This study covered 411 stores and indicated that the retail margin varied from 54 per cent to 118 per cent. The work was carried on through the New York office of the Division in co-operation with the Bureau of Plant Industry.

PUBLIC MARKETS

During the year questionnaires were sent out to all the cities of the state in an effort to secure information concerning the equipment, costs, and methods of operation of all public markets. The material so gathered has been summarized and tabulated, making available fairly complete information concerning existing public markets in the state. Progress has also been made in securing plans and working drawings of successfully planned market buildings in cities outside the state with a view to having available model plans for such structures when the same are needed. A special pamphlet has also been printed summarizing the advantages and disadvantages of public markets in the system of food distribution.

PUBLICATIONS

The following published material of the Division was prepared during the year by the bureau:

Bulletin (Foods and Markets Vol. 2 No. 17), "Egg Marketing — the Consumer's Viewpoint."

Pamphlet, "The Public Market."

Pamphlet, "Proposed Grades for Potatoes."

Pamphlet "Proposed Grades for Onions."

Article "A Program for Marketing Reform."

MISCELLANEOUS ACTIVITIES

In addition to the work alreay described the bureau carried on a wide range of other activities, the more important of which are as follows: Surveys of Cattaraugus and Chenango counties with reference to the possibilities of developing rural motor truck routes (carried on in co-operation with the National Automobile Chamber of Commerce); the taking of moving pictures of the New York City fruit and produce market (carried on in conjunction with the New York office of the Division); survey of barge canal with reference to transportation of agricultural products (carried on partly by the agents of the bureau and partly by agents of the Division); an investigation of the municipal recreation piers of New York City with reference to the possibility of using same for handling food products; an investigation of the business of the Clarkson Milk Company of Troy, N. Y.; and, lastly, the preparation of tentative state grades for onions and potatoes.

BUREAU OF COOPERATIVE ASSOCIATIONS

During the year this Bureau has been instrumental in organizing 136 associations. Nineteen different lines of activities are represented as follows:

Among producers:			
Maple products	17	Grapes	8
Dairy products	7	Market gardeners	3
Potatoes and cabbage	21	Hay	1
Canning crops	11	Cattle breeders	1
Wool	9	Swine breeders	1
Fruit	20	Teasel growers	1
Seed oats	1	To purchase supplies	16
Honey producers	6	To manufacture shoes	1
Among consumers:			
Stores	10		
Housing	1		
Restaurant	1		

In taking care of necessary follow-up work with associations organized previously and in accomplishing the above outlined work, 271 meetings were held, 256 conferences, and 16 special investigations were made by the Bureau. This does not include the meetings and conferences attended by the Director, or the Oragnizer established at the New York office.

The great problem of the Bureau at the present time is not creating new organizations, but in keeping the trend of co-operative marketing in the proper channel. Besides the usual directing work of the Bureau, efforts have been largely along that line, attending conferences with the leaders of different lines of activity, assisting them to shape the proper policies for the best conduct of their particular associations and seeing that new organizations based on state-wide endeavors, were planned on a basis that would bid for their success.

After July 1, the staff was increased by the addition of an accountant, who since that time has held 7 meetings and 18 conferences, and has established accounting systems for 19 associations. Associations organized under the three co-operative laws make annual reports to the Department.

A motion picture film illustrating the organization and methods of operating co-operative packing houses and the sale of fruit was developed under the auspices of this Bureau. The film was shown at least fifty times in the western fruit section of the State, in the Hudson Valley, and at the New York State College of Agriculture and the secondary schools. It was a very strong factor in the establishment of the packing houses throughout western New York.

Organization work is being conducted by the Bureau as follows:

CHAUTAUQUA GRAPE BELT

In the reorganization of the old Chautauqua and Erie Grape Growers' Association, which had been operated as a stock corporation, there have been organized seven local associations, which have in turn organized a central

sales association, all under Article 13-A. During the season just past, 1,400 carloads of grapes were sold by this association, its business amounting to $4,000,000. The average price was about $130 per ton, in contrast to the price of $100 received by the growers in unorganized territory, the difference in price representing the extra middlemen's profit. So much difficulty was experienced by this association in obtaining packages in which to market grapes, and the exorbitant prices demanded by manufacturers, that they organized and incorporated a package-manufacturing association under Article 3, which is operating at the present time, and has been instrumental in a very material reduction in prices demanded by outside manufacturers.

CANNING CROP GROWERS

Due to insufficient and ununiform prices paid to canning crop growers throughout the state for their products came about the demand for organization among canning crop growers. Two county associations organized in 1919, ten county associations in 1920, and the state association was created by the twelve county associations. The state association recommended a uniform contract to be issued by each of the county associations in the sale of their products to the canning companies. Uniform prices for standardized products of the same quality were also recommended. The state association disseminated marketing information to each of its county members. It is estimated by leading authorities throughout the state that the canning crop growers saved about $1,000,000 during the season through this organization.

FRUIT GROWERS

Twenty-two central packing houses were operated in the western part of the state. These associations graded to a common standard and sizing. During May, there was organized and incorporated the Western New York Fruit Growers Packing Association which was destined to be a central sales agency for the central packing association in the western New York fruit belt. Through this channel the packing of fruit of each of the member associations was supervised by a manager who visited the different associations regularly during the packing season. This brought about a thoroughly uniform pack. These associations have been selling apples to one of the leading chain store organizations during the past season with very satisfactory results; prices to the members have ranged from 50 cents to $1 per barrel more for this standardized fruit than was obtained by unorganized growers. Two associations were organized in the Hudson Valley which are preparing for the 1921 season.

POTATO MARKETING

Seventeen local associations were established in central New York. Representatives of these associations organized and incorporated a central sales association to handle the business at the locals. A manager was employed by the Central Sales Association and opened an office in October at Cortland. During the season, in which there was very little demand for potatoes, this association reports an average saving to its members of 12½ per cent. This association also handled a large number of cars of cabbage until market conditions became so bad that cabbage could not be moved.

MAPLE SAP PRODUCERS

The success of a county association organized to handle the 1919 crop led to organization in four counties to handle the 1920 crop. One association made a saving to their members of 85 cents per gallon; another was able to procure for the standardized products of its members 75 cents per gallon more than was being paid unorganized producers in that county. Another purchased a building and equipped it with modern bottling machinery. Syrup is going out from this organization in glass and under a brand and trademark name.

During November and December, fourteen local associations were organized and incorporated in northern New York to handle the 1921 crop of its members. About this time there came about a state committee of producers who were working on plans for a state or national sales organization.

BEEKEEPERS

During 1920 twelve county associations and a state association have been organized and incorporated. The state association has offices in Syracuse and is conducting a campaign through which they expect to organize fifteen or more counties. The purpose of the organization at present is to stabilize prices, grades, and packages, and to improve distribution and marketing conditions. At the present time all of the locals are purchasing supplies for their members.

WOOL GROWERS

Nine county associations have been incorporated by this Bureau during 1920, each one of the county associations becoming members of the State Federation. The Federation engaged a grader and general manager for the 1920 season. Through him the officers of the Federation brought about a successful pool of nearly 500,000 pounds of wool belonging to the member associations. This wool has been stored in a G. L. F. warehouse at Syracuse, where it has been graded ready for sale to manufacturers who buy entirely by grades.

WORK AMONG CONSUMERS GROUPS

July 1st, two organizers who were specialists in consumers' cooperative organizations became connected with the Bureau — one established at the New York office to take care of the large volume of work in Greater New York; the other to take care of the increasing work upstate. A state-wide survey of existing consumers' cooperative associations by means of a standardized questionnaire was made and data collected and placed on file in our offices. Believing that the most effective assistance could be given cooperative societies by providing for sound methods of administration, a great deal of data was collected and disseminated on store management, bookkeeping and accounting, bonding and market information. A special study of cooperative housing was made and a special pamphlet presented as a guide to groups of people contemplating cooperative housing.

Outside of New York City, seven cooperative stores were organized and incorporated. In New York City seven cooperative organizations were incorporated. The New York City organizer also held 76 meetings and 290 conferences with groups of people interested in cooperative organizations. The assistance given to existing cooperative associations has greatly increased their efficiency in conducting their business. The New York organizer has been instrumental in putting many of the cooperative stores in direct contact with producers' organizations from which they have purchased supplies.

BUREAU OF WEIGHTS AND MEASURES

This Bureau is charged with the enforcement of certain sections of the General Business Law, in accordance with which the Bureau must conduct a certain amount of routine inspection, the principal ones being as follows:

1. Testing of weighing and measuring devices used in checking the receipt and disbursement of supplies in the state institutions.
2. Inspection of the work done by city and county sealers.
3. Inspection and calibration of the standards used by city and county sealers.
4. Making of tests on all weighing and measuring devices submitted by manufacturers and issuing certificates of approval before such devices can be sold or used in the State of New York.

The foregoing work has been carried out and results obtained have been compiled and tabulated and are attached to this report.

The primary object of the Bureau of Weights and Measures is protection against inaccurate or false weight and measure, and this Bureau endeavors to secure such protection for every citizen, whether he be producer, manufacturer, merchant or consumer. This particular phase of the work brings the general public and the weights and measures officials together on a basis of better understanding regarding weights and measures laws and regulations,

a condition which should exist if hope may be entertained for universally accurate weights and measures.

The following is a brief resume of some of the special investigations conducted during 1920.

MILK RECEIVING STATIONS

This Bureau received a number of requests to take up the methods of weighing milk at creameries and milk-receiving stations.

Upon examination of the scale used by one receiving station it was found that one of the bearings was broken, which caused a shortage of two pounds on each weighing made. In another case it was found that the scale was not sensitive enough, due to hard usage and dull bearings.

Upon receiving a request from The Bryant & Chapman Company of Millerton, Dutchess County, N. Y., this Bureau investigated and tested scales of this company located at their milk-receiving station at Salt Point, Dutchess County. The scale at Salt Point was causing a loss to the milk company of seven pounds on each weighing being made. This scale was ordered repaired. At Cooks Siding, Columbia County, the scale owned by the Bryant & Chapman Company was found to be accurate. At the Silvernails plant of the Bryant & Chapman Company, Columbia County, the scale in use was found to be causing a loss of three pounds to the company on each weighing made over the scale located at this plant.

Complaint was received by this Bureau from a farmer in Cayuga County regarding the scale used at a milk-receiving station located at Martville, N. Y. Upon investigation it was found that the scale used at this place of business was accurate. However, upon testing the scale of the complainant it was found that it was not at all dependable.

RAILROAD TRACK SCALES

A special investigation and test was made of a wagon scale owned and operated by a dealer and buyer in feed and grain located in Otsego County. Upon investigation it was found that the scale was old and in very poor condition. A 4,000-pound load on the scale showed a loss to the seller of 200 pounds. It is readily seen that scales in this condition when used by merchants and buyers in rural districts where wagon scales are not at all common, would cause a number of farmer to suffer a large financial loss. As a result of our inspection the scale was adjusted for temporary use and the owner has since replaced it with a new up-to-date accurate scale.

HOUSE SCALES

Upon the request of a potato buyer of Warren County, this Bureau investigated and tested the scales used in the freight house of the D. & H. R. R. Company at Thurman, N. Y. Inspectors from this Bureau found that this scale was practically correct with the exception of some faulty weights. One of the weights belonging to another scale was being used, with the result that an error of 1,000 pounds was made on every weighing over 3,000 pounds. The loss to the shipper in this particular case was $330. Through the efforts of this Bureau the potato buyer was able to make an adjustment with the farmers from whom he purchased the potatoes. The weight in question was confiscated by the inspector of this Bureau and the railroad officials notified regarding the carelessness of the employee responsible for this condition.

SHORT WEIGHT POTATO CASE DUE TO FAULTY SCALE

A Paterson, N. J., produce company complained to this Bureau regarding a shipment of potatoes from Apalachin, N. Y. Our investigations disclosed the fact that the scales used in the sale of potatoes in this case had been broken and repaired by someone not familiar with the construction of scales. It developed that on each 100-pound weighing made on these scales there was an error made of 8 pounds. The scales were condemned for repairs and a satisfactory adjustment between seller and buyer made.

INVESTIGATION OF SALE OF BERRIES TO CANNERIES

More than 400,000 quarts of berries were inspected. A number of variations were found, some being short measure and some over. An official of one of

the canneries stated that the investigation had saved his firm over $500. On the other hand, a great many of the growers expressed their satisfaction due to the fact that some canneries were insisting on more than 20 ounces to the quart, which was the amount for which their contracts called.

METHOD OF SELLING GRAPES

This investigation was conducted in the Keuka, Westfield, and Fredonia districts, the purpose being to secure data which would aid the Bureau in the formulation of a regulation covering this particular commodity. The inquiry showed such regulation is needed on account of the wide variation due to moisture and trade customs in the different localities.

PERSONAL WEIGHING SCALE INVESTIGATION

A state-wide investigation was conducted regarding the accuracy of personal weighing scales, sometimes referred to as penny-in-the-slot weighing devices. Whenever the inspector found these scales not weighing accurately they were condemned and ordered removed until repaired. It was found that only 60 per cent of the personal weighing scales inspected were correct. The variation of errors noted ranged from 3 pounds to 15 pounds on a 100-pound test. Twelve different types of scales were tested.

STATE-WIDE COAL INVESTIGATION

During the late fall of 1920 this Bureau conducted an investigation regarding the methods and practices employed in the sale of coal. Of the loads of coal reweighed, 77 per cent were found to be correct, 17 per cent were found to be short weight, and 6 per cent of the loads reweighed were slightly short weight. Four cases were found which warranted prosecution and were therefore submitted to the Attorney-General's office.

REWEIGHING OF FOOD PACKAGES

Each state weights and measures inspector is instructed to reweigh as many packages about to be delivered by grocers and butchers as time and circumstances will permit while he is engaged in his regular inspection of the weighing and measuring devices in such places of business. In addition to this a special investigation was made in one of the larger cities with the result that 32 per cent of the packages of food about to be delivered to the purchasers were found to be incorrect in either weight or measure.

EDUCATIONAL MATERIAL PUBLISHED DURING 1920

During the first part of the year this Bureau prepared a booklet known as "Through the Door of Thrift by the Way of Accurate Weights and Measures." This booklet contained weights and measures information useful to housewives and others, including teachers of home economic classes from whom we have several hundred letters containing favorable comments and expressions of appreciation.

An organization bulletin known as "The Sealers' Monthly News Letter" was prepared by this office each month and copies sent to each sealer in this state, the primary purpose being to stimulate interest and proper coordination.

CONFERENCES

Important conferences relating to weights and measures activities were held. The principal ones were two conferences held with representatives of the baking industry with uniform and desirable legislation as the object.

A conference with the committee of city and county sealers of weights and measures regarding legislation was also held.

The Bureau assisted in the annual convention of the New York State Sealers of Weights and Measures Association, which was held in the Assembly Chamber of the Capitol during June.

PROSECUTIONS

Seventeen cases have been submitted to the Attorney-General for prosecution. In addition to these prosecutions, this Bureau assisted the local county and city sealers of weights and measures in prosecuting a number of cases.

LABORATORY TESTS

The following list of apparatus has been inspected, tested, and passed upon in the laboratory during the past year. These tests are known as precision tests and consist in comparing the apparatus submitted for test with the state standards and, where possible, in adjusting such apparatus to within stated tolerances.

Scales	32
Weights	772
Measures	272
Miscellaneous	44
Total	1,120

BUREAU OF FOOD PRODUCTS

The activities of the Bureau of Food Products have to do with the enforcement of the law against the adulteration and misbranding of food products and requires the making of inspections of retail stores, vinegar plants, food manufactories, restaurants, and other places where food is prepared or sold. These inspections include the taking of samples for laboratory tests, the making of cases for violations of the law and reporting same, and the informing of manufacturers and retailers as to the rules and regulations concerning the food products handled.

During the year 1920 there were 12,220 store inspections made by the agents of this bureau. The following table shows the number of food commodities sampled, of which there were 2,553 submitted to the laboratories for analysis:

Commodity	Number	Commodity	Number
Allspice	20	Mexene	1
Apple butter	14	Mustard	38
Apples, chops	2	Mustard, prepared	7
Apples, dried	118	My-T-fine	1
Apples, pomace	1	Nectarines	1
Apples, skins and cores	7	Noodles	23
Apricots, dried	59	Nutmeg	3
Baking powder	107	Oil, table	89
Beverages	310	Olives	13
Bread	33	Oyster broth powder	1
Buckwheat flour	1	Paprika	13
Caponatina	1	Peach butter	1
Catsup	45	Peaches, dried	73
Cherries	1	Peanut butter	6
Chocolate	31	Pear butter	1
Cinnamon	5	Pears, dried	18
Citric acid	1	Pectin	1
Cloves	1	Pepper	59
Cocoa	10	Pepper, red	24
Cocoanut	21	Pickles	3
Codfish	1	Pie crust	1
Coffee	77	Pie filling	12
Coffee, condensed	3	Pimentoes	1
Consultation	1	Preservative	1
Cranberries, dried	1	Prunes	35
Cream tartar	1	Pudding powder	2
Cream whip	1	Raisins	76
Currants	39	Relish	1
Egg, powdered	14	Saccharin tablets	3
Egg substitute	102	Sage	3
Fam-ly-ade	2	Salad dressing	3
Figs	6	Salad, egg plant	1
Flavors	8	Sauce	4
Fruited oats	1	Sauerkraut	1
Fruited wheat	1	Shortening	1
Gelatin	29	Soil	1
Ginger	1	Sauersalt	3
Honey	110	Sugar	3
Ice cream	26	Syrup	11
Jam	3	Tomato, canned	3
Jelly	6	Tomato paste	33
Jelly powder	2	Tomato pulp	1
Kream krisp	1	Tomato sauce	25
Macaroni	83	Tryphosa	1
Mace	2	Turmeric	1
Maple it	1	Vanilla	5
Maple sugar	98	Vegetable compound	1
Maple syrup	112	Vegetables, dried	1
Marshmallow	1	Vinegar	399
Meat	22	Yeast	10
Meat, potted	2		

INSPECTIONS OF STORAGE EGG SALES

In addition a total of 1,558 inspections for the purpose of checking the fraudulent sale of storage eggs in retail stores were made by the department's agents in New York City and 65 violations were referred to the Attorney-General, 14 of which were still pending in court on January 1, 1921. Samples to the number of 232 were taken. The penalties collected in cases made by the department against retail grocery stores in New York City for selling cold storage eggs without labeling them as such, amounted to the end of the year to nearly $1,200. Follow-up cases numbering 167 are now receiving the attention of our agents.

Vinegar factories have been inspected and samples of their output have been taken and submitted for analysis. Tests for acidity of the miscellaneous samples of vinegar sent in by individual farmers have been made and reported upon.

In cooperation with the Bureau of Food Standardization, special attention has been paid to the collection and analysis of the following food commodities: vinegar, maple sugar, maple syrup, honey, honey compounds, table oils, peanut butter, soft drinks and other beverages, compressed yeast, gelatin, egg substitutes, and baking powder, and to the labeling of various dried fruits. Where violations of the law have been found cases have been forwarded to Counsel of the Department for such consideration as the facts may warrant.

Especial attention is called to the fact that in order to interpret the pure food laws of the State and to show the correlation between these laws and the federal regulations, the Council of Farms and Markets has adopted during the year a set of definitions which will assist both large and small manufacturers of food products to comply with the law with regard to content and labeling of products. A copy of these definitions was published in "Foods and Markets" for November, 1920.

BUREAU OF FOOD STANDARDIZATION

Samples received by the Bureau of Food Standardization from the Department for examination during the year 1920, numbered 2,959. All of these have been tabulated to show the nature of the material examined each month and the amount of each received during that period. Important individual subjects and the chemical work done on them have been tabulated in separate individual sections of the report but these tabulations cannot be reproduced here owing to space restrictions. Same are on file in the Department, however, and open to public inspection.

Expenditures for the laboratory personnel show a marked decrease, the total for the fiscal year 1920–21 being less by more than $8,700 than the appropriation for the same purpose, the fiscal year 1918–19.

From the Finance Bureau of this Department a statement has been secured for the last six years of the actual cost for rent of chemical laboratories and salaries paid chemists engaged therein, as follows:

Year	*Amount Paid*
1916–17	$19,770 00
1917–18	20,000 00
1918–19	24,530 00
1919–20	18,250 00
1920–21 less than	15,756 63

CONFERENCES

Important conferences with representatives of the baking powder manufacturers of the country were held on February 9, 23, and 25. The Director of the Bureau presented to these conferences a definition and standard for baking powder, with which all baking powder makers should comply. At the conclusion of these conferences a definition was framed which was acceptable to all the manufacturers and their representatives present, and which the Director of the Bureau agreed to recommend to the Department for approval and for enforcement in this state.

The Director of the Bureau was also present on March 12 and 19 at conferences which the Commissioner of Foods and Markets had called with representatives of the dried fruit manufacturers. The object of this conference was to reach some agreement, if possible, as to the percentage of moisture and sulphur dioxide which should be permitted in such products. The stenographic notes of what was accomplished has been reported, but unfortunately no definite decision was arrived at in regard to the main questions at issue.

During the year the Director has been called at various times to be present at conferences, which had been requested by manufacturers or their attorneys with the counsel of the Department, with reference to products which had been found by the Department to be misbranded or adulterated.

Court appearances for the Department during the year were six in number, these being prosecutions of oleomargarine, milk, and vinegar cases.

CONCLUSIONS

It is believed that a careful constant inspection of food articles offered for sale in the state and careful examination of such material in the laboratories are absolutely essential for the state, if the purity of its food products is to be maintained. Although no gross or poisonous adulterations of foods have been discovered during the year 1920, the work of the year will show many cases of misbranding and petty efforts to deceive the public and increase the price of a commodity by some false labeling.

REPORTS ON VARIOUS FOOD PRODUCTS

Baking Powder

With reference to the definition adopted by the Council for baking powder, it was thought that a much fairer definition than the one adopted by the United States Department of Agriculture could be formulated for this state, and after conferences with representatives of nearly all the interests concerned in the manufacture of baking powders a definition was agreed upon which was entirely satisfactory to all of the baking powder interests represented, except in one particular. This one particular was in the amount of available carbon dioxide which should be required. This Department had suggested 12 per cent to conform in this particular to the Federal standard. Some of the manufacturers would have preferred a 10 per cent standard.

The definition which was promulgated and which was afterwards approved by the Council of Farms and Markets is as follows:

> Baking powder is a leavening mixture compound of acid reacting constituents and alkaline carbonates in proper proportions to liberate carbon inert material which tends to prevent premature chemical reaction between the first mentioned constituents.
>
> It should yield not less than twelve per cent (12%) of available carbon dioxide.
>
> Any leavening mixture composed of the constituents stated above, manufactured to yield less than twelve per cent (12%) of available carbon dioxide, must contain on the label of each package a plain statement of the minimum amount of available carbon dioxide which it will yield.
>
> Among the acid reacting materials used in baking powder are: (1) tartaric acid and or its acid salts, (2) acid salts of phosphoric acid, (3) sodium aluminium sulphate or aluminium sulphate, (4) combinations of classes (2) and (3).

It was also agreed at the conference with the representatives of the baking powder manufacturers that the Department would also require that baking materials should be as free from metallic impurities as it was feasible for the manufacturers to make them. The tolerances or limits to be permitted for arsenic, lead, zinc, flourid or other similar material would be accepted and established the same as such limits established by the United States Department whenever such limits should be definitely fixed.

By the official method sixty-five of the 106 samples of baking powder show a percentage of available carbon dioxide under 12 per cent, 39 show a percentage of available carbon dioxide under 10 per cent.

By the modified method, described above, 51 samples of the 106 show available carbon dioxide under 12 per cent and 25 show available carbon dioxide under 10 per cent.

In this class of materials, under the New York State law, the law has been interpreted to require that all constituents shall be named on the label. On three of the samples submitted during the year no constituents were given.

Beverages

The laboratory has received and examined during the year 310 samples of beverages or so-called soft drinks. In all cases determinations have been made of the specific gravity of the material at 20 degrees centigrade, of the amount of solids, of the acidity (this acidity calculated as citric, malic or tartaric acids), of preservative and saccharin, and for any added color. The results of these determinations have been tabulated and are on file.

A definition of fruit juice beverages has been approved by the Council of Farms and Markets, which in part reads as follows:

> The name of a fruit when used in conjunction with such terms as ade, squash, punch, crush, and smash can be correctly applied only to beverages, either still or carbonated, which contain the fruit or juice of the fruit named. Such terms should not be applied to products flavored only with essential oils or essences.

Of this class of materials during the year the tabulation shows the results of the examination of 68 samples of orange-crush, fourteen samples of lemon-crush, eleven samples of orange-squeeze, thirteen samples of grape smash, and one sample of cherry smash.

A definition for "phosphate beverages" has been approved by the Council of Farms and Markets. This definition reads in part as follows:

> Examinations of certain products sold or labeled as phosphate beverages have shown the presence of little or no phosphoric acid or acid phosphate. A product sold or labeled as a phosphate beverage which does not contain an appreciable amount of phosphoric acid or acid phosphate will be regarded by the Department as in violation of the food law.

Of materials of this class the tabulation shows the results of the examination of five samples of orange phosphate and four samples of cherry phosphate.

The tabulation also shows the results obtained with a great variety of material labeled in various ways. Nearly all of these samples are imitation products and, without question, should be so labeled and the label should show the constituents of which they are composed.

Bread

Thirty-three samples of bread were analyzed. These samples were all purchased in Albany and in nearly every case the bread was known to have been purchased in a fresh condition, in some cases it was still warm from the oven. The dates of these purchases are included in the tabulation.

The bread was weighed in each case immediately upon its receipt and the weight which we found has been tabulated. The weight was given on only eight of these samples. The price is also given and the cost is figured in each case to 100 ounces. It is interesting to note from this tabulation the variation in the weight of the loaves and the variation in the cost price for the same weight.

In the examination of this bread, determinations were made of the water content, of protein, of fat, of ash, of salt in the ash, of salt free ash, of acidity, and of carbohydrates and fiber.

Cocoanut

Of the twenty-one samples of cocoanut, received during the year 1920, at least ten have been labeled to show sugar when it was present. In three cases an unsweetened cocoanut seems to have been sold. From the information forwarded to this Bureau with the other eight samples there is nothing to show that the eight are not all misbranded.

Powdered Eggs and Egg Substitutes

During the year the Bureau has been called upon to examine 14 samples of powdered egg and 102 samples of egg substitutes. Of the powdered eggs all but two of the samples seemed to be free from adulteration. Two were adulterated with corn starch.

The examinations of the egg substitutes indicate that this material is a compound composed very largely of starch with a small amount of baking powder constituents, 65 of the 102 samples containing artificial color. The only purpose that the addition of this yellow color could serve would be to make the compound appear similar to a true egg powder.

Fruits, Dried and Evaporated

Under this heading the laboratory received and examined during the year:

Apples, evaporated	118
Apricots, dried	59
Peaches	73
Pears	18
Nectarines	1
Prunes	35
Currants	39
Figs	6
Raisins	76
Total	425

The determinations which were usually made upon this material were the determinations of water and of sulphur dioxide. The tabulation shows the results obtained expressed in percentages, and also gives any statement which was contained on the package indicating whether or not the material had been bleached or treated with sulphur dioxide.

As stated in the report for the year 1919, based on the results of these examinations, treatment with sulphur dioxide or sulphites seems to be almost universal in the preparation of dried fruits. In case only small quantities of the sulphite or free sulphur dioxide is left in food products and a plain statement is made on each package that such material is present, it would probably be impossible successfully to prosecute a case for violation of the law, based upon the contention that the food product was injurious to health because of the presence of this preservative. I believe, however, that the limit should be determined and fixed beyond which the presence of sulphur dioxide may render the food injurious to health and that there should be rigid enforcement against any excess of the maximum amount so determined upon. Special attention is called to the large amounts of sulphur dioxide which have been found in both years 1919 and 1920, in the dried apricots, in dried peaches, in the dried pears, and in some of the other material.

There is no state law in regard to the percentage of water which may be permitted in dried fruits, except in the case of evaporated apples.

Gelatine

Gelatine is a substance obtained from the nitrogenous substance of bones, hide, horns, connective tissues, tendons, and other nitrogenous matter of animals. When intended for food purposes it should be made from sanitary material.

It is usually found to contain small amounts of sulphur dioxide or sulphites which have been used for bleaching. It also frequently contains traces of arsenic, copper or other metallic impurities.

During the year, twenty-nine samples have been received at the laboratory and the results of the examinations have been tabulated. Determinations were made of water, nitrogen, ash, sulphur dioxide, arsenic, polarization of a three per cent solution at 15 degrees and at 35 degrees centigrade, and also the jelly strength of a two-per-cent solution. Work has been done by the Bureau of Chemistry in Washington showing that gelatines of the highest jelly strength also show a maximum value of mutarotation measured between

35 degrees and 15 degrees centigrade. These determinations were made on nearly all the samples of gelatine and the results substantiate the claim.

The percentage of sulphur dioxide was determined in twenty samples and it was found to be present in amounts from a minimum of 0.0064 per cent to 0.0366 per cent. It was found present in every sample that was tested.

Arsenic was determined in every brand submitted. The determinations were made in twelve samples and by the Gutzeit test. Arsenic was found to be absent in three brands. It was found to be present in nine, the amounts found varying from a minimum of 0.4 parts per million up to 2.0 parts per million.

Honey

The laboratory has received during the year 29 samples of honey and honey compound and the results of the examination have been tabulated. Some of the samples labeled " honey " were found to be adulterated with invert sugar. A number of the samples labeled " compound honey " are probably misbranded under our law.

Ice Cream

Twenty-six samples of ice cream were examined, all of which were obtained from manufacturers in or near Albany. Determinations were made of the sugars, solids, fat, nitrogen, ash, and acidity, which have been tabulated.

Among the constituents that were found to be used in these ice creams were cream, milk, condensed milk, powdered egg, gelatin; and for sweeteners, besides ordinary sugar or sucrose, were also found corn sugar and invert sugar.

The materials that are used in ice cream seem to vary to a very great extent and there seems little prospect of any real agreement among the manufacturers themselves on any one set of constituents. The only thing in which any agreement might be expected would be the establishment of some standard for the minimum percentage of milk fat that a cream should contain.

To indicate to what extent manufacturers of ice cream are using or desiring to use materials that are entirely foreign to ice cream as originally made and sold, we would quote from a recommendation of the National Association of Ice Cream Manufacturers as to what its composition should be:

> Ice cream consists chiefly of a sweetened and flavored mixture of cream, or cream and milk, or milk, with or without added milk fat in the form of sound sweet butter or as contained in condensed, evaporated or concentrated milk or in milk powder, and with or without added milk solids not fat in the form of skim milk powder or as contained in milk powder or in condensed, evaporated or concentrated skim milk or of a sweetened and flavored homogenized or emulsified mixture of sound sweet butter, milk powder, or skim milk powder and water, with the addition of gelatine, vegetable gum, or other wholesome stabilizer.

It would seem as though an article that could be of such extremely variable composition, as indicated by this recommended definition of the National Association of Ice Cream Manufacturers, is hardly entitled to be considered as an article, sold under its own distinctive name, with a definite composition: but should be considered only as a food compound with the requirements that the constituents actually used should be stated.

Table Oil

Eighty-nine samples of table oil have been received for examination during the year. The analysis of this material consisted in making determinations of those constants which were judged most likely to give indications of purity, or give some indication of what the individual oils were in the case of mixtures. The constants on any given oil vary somewhat, but these variations are within rather narrow and pretty well understood limits.

The determinations which have been made in every case were those of specific gravity, iodine absorption, and Halphen reaction. Where other determinations have been deemed helpful, in certain individual cases determinations have been made of flash point, maumene number, and specific temperature, of Tortelli-Ruggeri reaction, of Baudouin reaction or of viscosity.

The tabulation shows characteristic results which were obtained for the various individual oils, and also the same constants for the compound oils.

Two samples of olive oil were found to be adulterated. At least two of the samples labeled to have been pressed from cottonseed were adulterated. The peanut oils in three cases give very positive evidence of the presence of cottonseed oil. In the case of miscellaneous oils, labeled salad, vegetable, compound, mixed, etc. — nearly all of these are misbranded under our law.

Ground Spices

During the year 171 samples of ground spices have been examined. As stated in my report for the year 1919 samples were taken that year, and the work was continued in the early part of this year, with the idea of covering all grinders of spices in the state and also representative samples from grinders outside the state. A complete list of the state grinders of spices was being compiled by the food bureau. Microscopic examinations were made in all cases and these determinations were supplemented in certain cases by other chemical determinations to show to what extent samples were found to be adulterated and misbranded.

Vinegar

There were received for analysis during the year, 280 samples of vinegar. Of these 93 labeled as cider vinegar, were passed. Two of the cider vinegar samples were broken and lost in shipment so that no examination could be made. Thirty-two of the samples labeled as cider vinegar were reported adulterated. There were 34 samples labeled vinegar, white vinegar, distilled vinegar, etc., many of which are violations of the vinegar law because of deficiency of labeling. There were also 47 samples which were received from the producers and in which the acidity was determined.

This is a smaller number of vinegar and cider vinegar samples than were examined during the year 1919, but the proportion of adulteration in the cider vinegar samples remains about the same. For the year 1919 the percentage reported adulterated, of the samples labeled cider vinegar, was 26.1 per cent. Percentage of samples labeled cider vinegar reported adulterated for the year 1920 is 25.6 per cent.

In connection with the analyses of the cider vinegar which were passed it is interesting to note that the average of vinegar solids for the whole number was 2.05 grams per 100 cc. For the year 1919 the average solids for the passed cider vinegars was 2.02 grams per 100 cc.

Yeast

It has been known for many years that yeast possessed food properties. It is claimed that the Germans, during the stress of the late war, were the first to make a comprehensive study of its nutritive possibilities. This work has been continued, notably in the laboratory of Physiological Chemistry of the Jefferson Medical College of Philadelphia. There a number of workers have studied metabolism of men and animals using a yeast diet.

The manufacturers of yeast have begun a campaign calling the attention of the public to yeast as a food. We quote some of these advertisements: "Yeast has an appetizing creamy taste. You eat from one-half to a whole cake three times a day before meals; or take it crumbled in water, fruit or milk. Yeast is not a drug or medicine. It is a food and a tonic, and as such should be taken persistently for best results." Another: "Yeast as a health builder. Science has discovered the remarkable curative powers of yeast. It is being widely and successfully used to promote good health."

The definition of yeast, approved by the Council of Farms and Markets, is the following:

> The term "compressed yeast," without qualification, means distillers' yeast without admixture of starch. If starch and distillers' yeast be mixed and compressed such product is misbranded if labeled or sold simply under the name "compressed yeast." Such a mixture or compound should be labeled "compressed yeast and starch," or in some similar manner. It is unlawful to sell decomposed yeast under any label.

BUREAU OF LICENSES

The Bureau of Licenses deals with the licensing and bonding of milk dealers who purchase milk from producers either for shipment to cities for consumption or for manufacture thereof; and the licensing of commission merchants who deal in farm produce, and of cold storage warehouses. Fees realized from such licenses are turned over to the State Treasurer.

There were 245 licenses issued to milk dealers under the provisions of Section 55 of the Agricultural Law for the license year beginning September 1, 1920. These 245 licensed milk dealers operate 996 stations in New York State, and the maximum amount of business done by these dealers for one month is estimated at $16,429,390.

In addition to issuing licenses, this Bureau directs the investigation of complaints filed by producers and prepares the evidence for submission to the Attorney-General in legal proceedings instituted against the licensee. This Bureau also has charge of the distribution of the proceeds of any bonds forfeited by the licensee through bankruptcy or the violation of the law.

How the bonding provision under Section 55 of the Agricultural Law operates to protect producers is shown in two cases during the calendar year 1920.

In one of these cases, the Ekenberg Co., Cortland, which had been required by this Department to furnish a surety bond in the sum of $25,000 went into bankruptcy. The case was immediately referred to the Attorney-General, and subsequently the bonding company paid the total claims of the milk producers amounting to $22,970.

In a similar case, the bankruptcy of the Diamond Creamery Co., Massena, which was bonded in the sum of $62,500 for the license year ending August 31, 1920, the bonding company paid the claims of milk producers to a total of $19,907, and the sum of approximately $20,000 was also paid in the same bankruptcy to milk producers for the license year beginning September 1, 1920.

A summary report of the Bureau for the period beginning January 1, 1920, and ending December 31, 1920, is as follows:

COLD STORAGE WAREHOUSE LICENSES

Number of cold storage applications and fees received from January 1 to December 31, 1920	95
Number of cold storage licenses issued from January 1 to December 31, 1920	90
Number of cold storage fees returned — cases did not come within the law	3
Number of cases now pending	2
Number of fees which the Director of Bureau of Accounts has been authorized to release to the State Treasurer, for which licenses have been issued	90—$2, 250

COMMISSION MERCHANTS' LICENSES

Number of applications and fees received from commission merchants from January 1, to December 31, 1920	652
Number of licenses issued to commission merchants for period from January 1 to December 31, 1920	649
Number of cases now pending	3
Number of fees which the Director of Bureau of Accounts has been authorized to release to State Treasurer, for which licenses have been issued	649—$6,490

MILK DEALERS' LICENSES

Number of applications and fees received prior to January 1, 1920 for which licenses were issued between January 1, and August 31, 1920	46	
Number of applications and fees received from January 1 to August 31, 1920	53	
Number of applications and fees received from September 1 to December 31, 1920	223	
		322
Number of licenses issued to milk dealers from January 1 to December 31, 1920		299
Cases now pending		23

(*Note.* These are current cases and are being followed up and affidavits being secured where necessary.)

Number of cases turned over to the Attorney-General for prosecution from January 1, 1920 to December 31, 1920	2
Number of fees which the Director of Bureau of Accounts has been authorized to release to State Treasurer, for which licenses have been issued	299—$2,990

The Bureau of Accounts is holding $200, fees received from twenty milk dealers whose cases were turned over to the Attorney-General for prosecution during the years ending August 31, 1918 and August 31, 1919.

(*Note.* These cases have again been referred to counsel asking for an opinion as to the disposal of these fees.)

FEES

Amount of fees received from milk dealers and released to State Treasurer	$2,990
Amount of fees received from commission merchants released to State Treasurer	6,490
Amount of fees received from cold storage warehouses released to State Treasurer	2,250
	$11,730

NEW YORK CITY OFFICE

The work of the New York City office of the Division developed greatly during 1920 in both volume and importance. Through this office were conducted all those activities of the Division relating to conditions in the New York City wholesale markets and having to do with the metropolitan population, These activities may be grouped as follows:

Market Reporting Service

Control of Malpractices and Investigation of Complaints against Commission Merchants

Facilitation of Contact between Producer and Market

Investigation Incidental to Licensing and Bonding of Commission Merchants and Milk Dealers

Special Studies of Costs of Marekting and of Conditions at Receiving Terminals

Assistance to Consumers' Cooperative Associations.

Campaigns to Improve Temporarily Serious Market Situations

Education of Consumers and Producers on Marketing Problems and Conditions

MARKET REPORTING SERVICE

The function of the New York City office in supplying to the farmers of the state complete and accurate information regarding prices and conditions in New York wholesale markets for farm products is of fundamental importance to the improvement of marketing conditions. The farmers of this state have the largest consuming market of the country at their door, but their products must compete with products from every part of the United States and from many foreign countries. Knowledge of market conditions is the basis of efficient marketing. The aim of the state market reporting service is to make available without expense to every farmer and shipper in the state the information that will enable him to dispose of his products intelligently. This service is intended to prevent waste from market gluts and to eliminate the old type of exploitation of the producer by the middleman who took every advantage of his ignorance.

The state reporting service is coordinated with the Federal reporting service, the two supplementing each other and meeting different needs.

The daily information collected in the wholesale markets by the department agents is made available to farmers throughout the state and to the general public by means of (1) the printed weekly report issued on Friday; (2) daily mimeographed reports issued the first four days of each week; (3) daily mimeographed news market summaries issued to newspapers every day except Saturday; (4) telegraphic information sent to farm bureaus, cooperative marketing associations, and information centers during the height of shipping seasons; (5) answers to inquiries by mail; (6) special newspaper releases describing conditions of public interest in the market.

The printed weekly report has been perfected during the year to a point where it is generally recognized as the most complete and accurate report of any kind on the New York wholesale markets for farm produce from nearby sections. The size of the weekly report was increased gradually to permit of more complete quotations until in the height of the shipping season it was double that of the previous year. In December 1920 the mailing list of individuals who personally requested weekly reports had increased from 3,700 of the year before to 5,453. In addition to these, 6,315 copies were sent each week in packages to farm bureau offices for remailing to farm bureau members, and 775 copies went each week to newspapers in the state. The total circulation of the weekly on December 4 was 12,600.

The daily mimeographed reports were enlarged during the shipping season to give those who were shipping perishable commodities every day the information they would need each morning as to the previous day's market. Through the help of the Bureau of Markets and Storage and county agricultural agents, information centers were established during the summer in fruit and vegetable growing sections to which daily reports were sent and from which the information was distributed to the farmers in the community. These information centers included farm bureau offices, stores, banks and cooperative associations. The mailing list of the daily reports increased from 90 to 524 during the year.

Market news summaries giving brief quotations of the markets up to 1 p. m. are now sent daily to every daily newspaper in the state that will use them. The weekly papers are classified according to the day they go to press and market summaries are sent to all of them so as to give them the latest possibly information up to that time. This market news service goes to 775 newspapers within the state.

Telegraphic market reports were a new development in 1920. Wherever farm bureaus or farmers cooperative associations desired to receive immediate information each morning during the height of their shipping season on the market conditions that morning, brief code telegrams were sent to them prepaid from the New York office, usually before 8 a. m. Individuals were sent the same information as fully as desired, on request, by collect telegram. Lists were also made up of farmers or farm organizations who desired telegrams if there was any sharp change in the market for a particular commodity, and telegrams were sent to them. The growers in the Hudson River

Valley counties availed themselves of this telegraphic service extensively in the summer and fall and reported that it saved them thousands of dollars in enabling them to ship with a full knowledge of the market situation. There is a wide demand for the extension of this service next season.

CONTACT BETWEEN PRODUCER AND MARKET

Over 500 inquiries were received during the year from farmers who wanted specific information as to where they could market their produce and how it should be shipped. These letters related to all sorts of farm products.

The assistance of cooperative associations of farmers to establish satisfactory contacts was given special attention. Whenever it seemed practicable these associations were put into direct contact with consumers' cooperative associations or with buying agencies for chain stores, restaurants, or other retail agencies.

COMPLAINTS INVESTIGATED

Every complaint from a farmer against a commission merchant or other dealer was given the individual attention that a business agent would give his client, except that the purpose of investigation was always to get at the exact truth of the matter in controversy and to act accordingly. Approximately 400 complaints were received and investigated during the year. The majority of these were against commission merchants on account of unsatisfactory returns and loss of farm products while in transit.

In the collection of claims for shippers the New York office usually was able to secure satisfactory settlement directly between receiver and shipper. In one case, for example, a claim of over $400 was paid directly to the shipper through the intervention of the Division. When necessary, however, the money was collected by the Division and forwarded to the shipper. Twenty-two such collections were made in the year and a total of $443.14 forwarded. The sums paid direct to farmers without passing through the Division's hands amounted to many hundreds of dollars.

INVESTIGATIONS OF LICENSEES

The licensing and bonding of commission merchants in New York City, and of city milk dealers who buy milk direct from farmers, involves a large amount of field investigation which is carried on by the New York office for the Bureau of Licenses.

Whenever a licensed and bonded firm fails or goes into bankruptcy, as happened in 1920 with four commission merchant houses and three milk dealers in New York City, a thorough examination of the firm's outstanding accounts is made at once to protect the interests of the consignor creditors and to determine whether attachment of the bond in their behalf will be necessary.

FOLLOW-UP OF SHIPMENTS

Any farmer shipping goods to the New York market may have his shipment followed up on arrival in the market by writing to the Division's office and giving name of carrier and shipper, commodity, and date of shipment. Those who ship regularly to one firm with whom their relations have been satisfactory have no occasion to do this, but those shipping to firms new to them are urged to protect themselves in this manner.

The number of shipments followed up this year was not large, averaging only from five to ten per month, but the shipments included a variety of commodities,— eggs, hay, beans, Belgian hares, veal, calfskins, lettuce, cabbage, tomatoes, live poultry and maple syrup.

TRANSPORTATION PROBLEMS

The railroad and harbor strikes and the general tie-up of transportation early in 1920 resulted in serious delay in the movement of fertilizer and seeds just at the beginning of the planting season. The New York office in conjunction with the Bureau of Markets and Storage took up the tracing of lost cars and secured the cooperation of the railroads in rushing them to destination. The principal difficulty was with the seed potatoes from Maine and

fertilizer from Baltimore and Pennsylvania. Hundreds of cars were located and their movements checked until they reached their destinations, after continuous telegraphing, telephoning, and personal visits to railroad offices and yards and to offices of fertilizer companies. This period of stress extended from the last of March to the end of May.

EGG BREAKAGE CAMPAIGN

The loss from breakage in shipments of eggs arriving in the New York market in the shipping season of 1920 was so great that a conference of railroad and express officials and wholesale egg receivers was held in the New York office in July for the purpose of finding the causes of the excessive breakage and of removing them. With the assistance of the trade papers, a large amount of publicity was secured locally and all over the country with regard to the waste of egg breakage and the problem of prevention. The Mercantile Exchange through its Traffic Committee adopted a comprehensive program proposed by the Directors of the New York office for activities on the part of various public, trade, and transportation agencies to eliminate the breakage evil.

In conformance with this program, the New York office circulated a questionnaire among all the principal receivers of eggs in this market to secure definite information as to the amount of breakage in receipts during May and June by freight, by express and by parcel post. The returns were not complete enough to make the results shown in the tabulation of this data very significant. The total percentage of damage shown in express shipments reported was 4 per cent and in freight shipments 0.82 per cent. These percentages are based on reports on express shipments of 14,771 cases and freight shipments of 227,196.

The New York office worked during the last half of the year with the American Railway Express Company, the State College of Agriculture, and the Albany office in testing new types of packages for shipping eggs.

HAY MARKET SURVEY

In the summer of 1920 a survey was made of the hay market facilities in Greater New York including all the railroad and boat terminals at which hay is received and sold. The capacity of each terminal in track space and storage space, the amount of hay handled, the methods of sale, and other information of value to hay shippers was secured.

At only three of these terminals is there any provision for storage of hay, and in these the capacity is very small. At all other places sales are made directly from the car or on the docks, and only a limited quantity can be received at a given time without congestion and depression of the market. Because of this situation the railroads instituted a permit and embargo system to check the incoming of hay whenever their tracks were full, resulting in a continual erratic fluctuation of prices.

EDUCATIONAL TOURS THROUGH MARKETS

For the purpose of acquainting farmers, students, teachers of civics and economics, and others with actual conditions in the wholesale food markets of New York City, the New York office conducted a number of night tours through the markets during the summer. These trips usually began about midnight and ended at 9:30 or 10 o'clock the next morning.

The groups represented in the market tours included the domestic science teachers in the public schools of Greater New York (150 went in one party), students and professors from Teacher's College, Columbia University, from New York University, from the New School of Social Work, from City College, and a party of Long Island farmers from Suffolk County.

APPLE WEEK CAMPAIGN

An outstanding accomplishment of the year for the New York office was the remarkably successful publicity campaign in November to increase the consumption of New York apples and to help move the big surplus crop. This

publicity campaign centered around "National Apple Week" October 30th to November 6th in the advertising of which the Division cooperated with the International Apple Shippers Association.

The Division of Foods and Makets printed and distributed 10,000 paper posters for display in retail stores during apple week, and 1,000 linen streamers for use on tracks and delivery wagons. The cooperation of chain stores, restaurants, hotels, lunch rooms, and all sorts of civic bodies was secured in advertising New York apples. Newspaper releases were issued every day and the metropolitan newspapers gave generously of their space. Every possible expedient was resorted to to make news of apples and the apple crop.

Over 15.000 attractive pamphlets describing New York apples and telling how to cook them, and over 5.000 button-hole red apple tags were distributed through the public schools. The domestic science classes in all the schools of Greater New York made a feature of the preparation of apple dishes during the week. An apple show and demonstration showing the proper way of cooking apples were held on three days at Teachers' College, Columbia University, under the direction of Miss May Van Arsdale.

As a means of giving the public an opportunity to buy apples cheaper than at the prevailing retail prices and in larger quantities than by the single pound or piece, an apple sale was opened on Fifth Avenue on November 2nd by the New York office in conjunction with the Consumers' Food committee. A good quality of hand-picked Baldwins were offered at 12 pounds for 25 cents. The rush was so great that policemen had to be called to keep the crowd in line and on the second day the merchants in the vicinity protested so that the owner of the building refused to let the sale continue. Over 1,000 people bought apples the first day.

The sale was moved on the third day to the Jefferson Public Market, where space was provided through the courtesy of the New York City Commissioner of Public Markets. It was continued there for a week and an enormous amount of New York apples were moved in quantities from a pound to five barrels at wholesale prices.

The sale met with such popular approval that another one in the Bronx was conducted in the same manner for a week in December. In the two sales there was a slight deficit after all expenses were paid, that was borne by members of the Consumers' Food Committee, but the sales resulted in adding much to the popularity of the New York apples.

STUDIES OF COST OF DISTRIBUTION

Since July 1, 1920, the New York office has been able to take up several investigations of a statistical character owing to the addition to its staff of a person trained for this work. First, attention was given to collection of accurate data as to the receipts and consumption of foodstuffs in the New York market, which is of primary importance in marketing work. Among other investigations, however, were two relating to the margin or "spread" between prices paid to farmers and prices paid by consumers.

RETAIL APPLE PRICE INVESTIGATION

With the help of apple grading inspectors of the Division of Agriculture, an investigation was made in October in New York City to determine (1) the extent to which New York apples were being sold in retail stores, (2) the prices of them and (3) the extent to which the city consumer was being given any inducement to increase consumption.

The Manhattan prices were secured from about 250 retailers and in Brooklyn from 160 retailers. A full report of the results, which involves too much detail to present here, was submitted to the Council of Farms and Markets. In brief, conclusion may be summarized as follows:

Whereas, the Western boxed apples were generally found to the exclusion of New York State apples on small fruit stands, the majority of regular grocers sold some variety or varieties of the New York State barrelled apples.

In Manhattan the average retail price of New York apples was found to be 6.9 cents per pound. By reducing what the farmer received per barrel to a pound basis, it was found that he received from 3.2 cents to 4.5 cents per pound for his apples. In other words, there was a difference from 2.4 cents to 3.7 cents between the price paid by the consumer and the price paid to the farmer. In terms of

percentages this means a margin from 53 per cent to 116 per cent between the retail selling price and the amount which was received by the farmer.

In Brooklyn the margin was even greater. The average retail price was 7.3 per pound, the average price paid the farmer ranged from 2.8 cents to 4.3 cents per pound. The difference between the retail price and the wholesale prices range from 3.0 cents to 4.5 cents or from 70 per cent to 161 per cent.

The investigation in Manhattan (Oct. 13 to Oct. 22, 1920) showed that 201 retail dealers (or 81 per cent of the total number) were not making any concessions to purchasers of larger quantities; 40 (or 16 per cent of the total number) were making concessions; 7 (or 3 per cent of the total number) said that there was no call for larger packages from consumers.

The investigation in Brooklyn (Oct. 28 to Nov. 4) showed that 150 retail dealers (or 94 per cent of the total number) were not making any concessions to purchasers of larger quantities; 10 (or 6 per cent of the total number) were making concessions.

STATISTICS AS TO FOOD RECEIPTS IN NEW YORK CITY

A problem with which any person or agency attempting to deal with the marketing of foodstuffs in New York City is immediately confronted is that of securing accurate data as to receipts and consumption in this market. There has never been any satisfactory coordination of the collection of data of this kind. At the present time any one who wants to get complete information as to the amount of foods that comes into the city and the amount consumed here, must go to not less than five different agencies and for some commodities to many more.

Toward the end of getting together the most complete and accurate data possible for a year's receipts of food commodities, a statistical investigation was undertaken by the New York office and continued intermittently during the last four months of the year, which has resulted in a report of great value to all marketing agencies. It contains in summarized form all the data available regarding receipts, consumption and export of fruits, vegetables, poultry, dairy and poultry products, meats, grains and other products. Tables were worked out showing the sources from which fruits and vegetables are received and the number of carloads of each commodity unloaded during each month.

REPORT ON CREDIT UNIONS

At the request of Commissioner Porter the New York office prepared an analysis of the state credit union law and its possible application to rural credit problems in this state. This report included a summary of material regarding rural credit unions in other states and countries which had been collected by the director of the New York office. A copy of the report was put at the disposal of a large county improvement association in central New York for use in working out plans for extending credit to small farmers.

OTHER SPECIAL STUDIES

In cooperation with the Department of Household Economics, Teachers' College, a number of special studies of marketing problems of special interest to the consumer were made through the help of advanced students. These included the following:

Cooperative Buying Clubs in New York City

A survey of the cooperative buying clubs operated among the employees of 25 different corporations or institutions such as the National City Bank and the Board of Education, which covers their methods of administration, the products carried, the merchandizing methods, amount of sales, estimated savings to members, costs of operation, etc.

Investigation of Brands Carried by Retail Stores

A study of the number of brands of the different commodities carried and the relation of the variety of brands to the cost of running the store.

Push-cart Markets, New York City

A study of the foods sold from push-carts and comparison of the prices with prices for same quality of foods in ordinary retail stores.

The Extent to which Farmers' Public Markets Could be Utilized by the New York City Housewife

An investigation of the two public farmers markets in Manhattan to determine whether they offer any prospect for more economical marketing to the average housewife.

Comparison of Package with Bulk Foods

A comparative study of foods sold in packages and the same materials sold in bulk, including an investigation as to the amount of sales by bulk and by package and the percentage of extra cost for package and advertising.

The Value of Knowing the Varieties of Foods in Purchasing Household Supplies

COOPERATIVE ORGANIZATION

Under the general supervision of the Bureau of Cooperative Associations, the New York office developed its activities for the assistance of consumers and producers cooperative associations quite extensively during the year. Early in the year a survey was made in conjunction with the Consumers' League of New York City. This was the first survey of its kind in recent years and it brought to light a large number of cooperative enterprises that were not known even among those in the cooperative movement.

The assistance given consumers' cooperative associations has been of two general types: (1) Aid in drafting articles of incorporation and by-laws and other help in initial organization of groups already formed for a definite purpose; (2) advice and information with regard to problems of operation and management. Hundreds of dollars have been saved cooperative groups by the Division of Foods and Markets in drafting and filing with the Secretary of State the articles of incorporation of these organizations in such form that they comply with the cooperative laws and provide proper safeguards for the operations of cooperative associations.

Talks and lectures on cooperative principle and management have been given to a considerable number of groups. Personal visits have been made to most of the cooperative organizations in New York City to ascertain their problems and methods of organization. Special inquiries were made with regard to cafeteria and restaurant societies, laundry operation, coal distribution, sources of supply of farm products of various kinds, and in regard to cooperative housing.

BUFFALO OFFICE

Routine work of the Buffalo office included market reporting; food inspection; issuing daily mimeographed copies of prices and conditions prevailing as they relate to the distribution and sale of these products; gathering and compiling statistical data relating to food commodities and their distribution; issuing daily mimeographed copies of prices and conditions prevailing on the Buffalo wholesale produce markets, mailing same to large producers, shippers, farm bureau agents, outside state and federal agents; assisting in organizing and directing cooperative organizations.

MARKET REPORTING

Wholesale prices and conditions prevailing on Buffalo wholesale markets are gathered and compiled daily by Mr. Doersam. From 150 to 200 mimeographed copies of this report are mailed daily to large producers, shippers and county agents. One morning, and two afternoon daily newspapers of this city, with an approximate circulation of 200,000 copies, are featuring this report: one paper at Auburn, one at Lyons, and one at Syracuse, also publish this report.

INSPECTIONS

The work of food inspection, gathering of samples, and observance of cold storage food rules and regulations, has been confined to Buffalo, and some of the nearby towns. This office circularized seventy cities and towns of three thousand inhabitants and over in Western New York, with copies of "Cold Storage Rules and Regulations," for the enforcement of Article 4-A of the Farms and Markets law of New York state. These were mailed to the health departments of the various cities and towns, and covered twenty counties.

Fifty-two bottlers of beverages such as pop, mineral waters, etc., of this city were circularized with copies of Article 80 of the Agricultural law, accompanied with a letter calling attention to this article, and also to Article 4 of the Public Health law. We are receiving responses by telephone, and personal calls, for advice on labeling of beverages, which, when put in concrete form, are submitted to Albany for official ruling.

COMPLAINTS AND INVESTIGATIONS

Complaints and investigations handled through this office dealt with the work of the different bureaus of the Division, inquiries dealing chiefly with licenses, weights and measures and marketing. Under the complaints investigated may be mentioned a few typical cases as follows:

Complaint in regard to consignment of chestnuts for which no returns had been made. Settlement secured.

Complaint by United States Department of Agriculture re carload of powdered milk with sugar reported to them by Frontier Chocolate Co., Tonawanda, N. Y. Referred to Albany.

Complaint in regard to carload of raisins at Dunkirk, N. Y., found to be unfit for food. Seized and destroyed by Federal agents.

Complaint made by a shipper at Odon, Indiana, against a commission merchant in Buffalo for failure to make returns for consignment of four barrels of rabbits. Settlement effected and check forwarded shipper.

Complaint made by commission merchant in regard to the practice of feeding live poultry in transit, and just previous to unloading for local markets. Investigated, and findings on file.

This office also took a food survey during the switchmen's strike, findings relative to which are on file.

STATISTICAL

Total number of car arrivals of perishable produce of all kinds received at Buffalo terminals as reported to this office:

Apples, 435; cabbage, 180; bananas, 370; celery, 122; grapes, 416; grape fruit, 209; lemons, 208; watermelons, 258; onions, 336; oranges, 974; potatoes, 1331; sweet potatoes, 204; turnips, 34; cranberries, 20; mixed vegetables, 113; prunes, 14; peppers, 38; quinces, 3; pears, 40; squash, 1; peas, 3; lettuce, 185; spinach, 13; strawberries, 12; peaches, 113; cucumbers, 93; mixed fruit, 21; tomatoes, 101; cauliflower, 22; pineapples, 46; asparagus, 3; cantaloupes, 353; total, 6271.

In season, the produce market of Buffalo is supplied principally from local production, delivered by truck or wagon, so that only approximate figures are available. It is estimated that an average of from two to four hundred loads reach the market daily. The foregoing does not comprehend the great amount of package produce shipped in small lots by express. This applies particularly to asparagus and lettuce, in and out of season, for which no data are available.

FINANCIAL REPORT

DIVISION OF FOODS AND MARKETS

STATEMENT OF APPROPRIATIONS AND EXPENDITURES FOR THE FISCAL YEAR JULY 1, 1919–JUNE 30, 1920

Chapter	Title	Appropriated	Total	Expended	Total	Balance June 30, 1920	Total
177-1-1919	Personal service	$132,940 00		$124,124 63		$8,815 37	
644-1-1919	Personal service	1,560 00		1,500 00		60 00	
177-1-1919	Personal service, salaries, temporary	2 500 00	$137,000 00	2,407 04	$128,122 57	2 06	$8,877 43
	Mai[illegible]						
177-1-1919	[illegible]	$7,500 00		$4,036 34		$3,463 66	
177-1-1919	[illegible]rts	17,500 00		11,984 80		5,515 20	
177-1-1919	[illegible]	11 500 00		8,904 95		2,596 05	
177-1-1919	[illegible]	45,000 00		37 630 42		7,369 58	
177-1-1919	[illegible]	14 000 00		8 808 29		5,191 71	
177-1-1919	[illegible]nent	5,500 00	101,000 00	4,011 38	75,376 38	1,488 42	25,623 62
	Totals chargeable to fiscal year, July 1, 1919–June 30, 1920		$238,000 00		$203 498 95		$34,501 05

BALANCES OF APPROPRIATIONS IN FORCE JULY 1, 1919, WITH EXPENDITURES CHARGEABLE TO PRIOR YEARS

Chapter	Title	Balance July 1, 1919	Total	Expended	Total	Balance June 30, 1920	Total
	Maintenance and Operation:						
571-1-1918	Printing, general	$5,415 24		$2,817 37		$2,597 97	
571-2-1918	[illegible]	303 79		42 70		261 09	
571-1-1918	[illegible]nt reports	14,530 73		5,972 03		8,558 70	
571-1 1918	[illegible]	500 00		219 60		280 40	
571-1-1918	[illegible]	743 32		464 37		278 95	
571-2-1919	[illegible]	129 72		126 50		3 22	
571-1-1918	Supplies	2,465 62		1 666 36		799 26	
571-1-1918	Traveling expenses	16,846 35		12,374 43		4,471 92	
571-1-1918	Communication	208 04		207 06		98	
571-2-1918	Communication	67 18		32 95		34 23	
571-2-1918	Rent	330 00	$41,539 99	280 00	$24,203 37	50 00	$17,336 62
	Totals chargeable to years prior to July 1, 1919		$41,539 99		$24 203 37		$17 336 62

RECAPITULATION OF EXPENDITURES

Personal service and maintenance and operation, July 1, 1919–June 30, 1920	$203,498 95
Total expenditures made during 1919–1920 for years prior to July 1, 1919	24,203 37
Total of all expenditures during fiscal year July 1, 1919–June 30, 1920	$227,702 32

RECEIPTS, JULY 1, 1919–JUNE 30, 1920

Commission merchants' licenses	$6,520 00
Milk licenses	3,400 00
Cold storage licenses	1,750 00
Total	$11,670 00

STATE OF NEW YORK

Thirty-third Annual Report

of the

New York State College of Agriculture at Cornell University

and of the

Agricultural Experiment Station

Established under the Direction
of Cornell University
Ithaca, New York

1920

A. R. MANN, Dean and Director
CORNELIUS BETTEN, Vice Dean of Resident Instruction
W. H. CHANDLER, Vice Director of Research
M. C. BURRITT, Vice Director of Extension

Transmitted to the Legislature January 15, 1921

Albany
J. B. Lyon Company, Printers
1921

THIRTY-THIRD ANNUAL REPORT

OF THE

New York State College of Agriculture at Cornell University and of the Agricultural Experiment Station Established under the Direction of Cornell University

---

STATE OF NEW YORK

DEPARTMENT OF AGRICULTURE

ALBANY, January 15, 1921

To the Honorable the Legislature of the State of New York:

In accordance with the provisions of the Statutes relating thereto, I have the honor to transmit herewith the Thirty-third Annual Report of the New York State College of Agriculture at Cornell University, as a part of the Twenty-eighth Annual Report of the Commissioner of Agriculture.

GEORGE E. HOGUE,
Commissioner of Agriculture.

NEW YORK STATE COLLEGE OF AGRICULTURE

STAFF OF INSTRUCTION AND EXTENSION WORK

Albert William Smith, B.M.E., M.M.E., Acting President of the University.
Albert Russell Mann, B.S.A., A.M., Dean of the College of Agriculture, Director of the Experiment Station, and Director of Extension.
Isaac Phillips Roberts, M.Agr., Professor of Agriculture, Emeritus
John Henry Comstock, B.S., Professor of Entomology and General Invertebrate Zoology, Emeritus.
John Lemuel Stone, B.Agr., Professor of Farm Practice, Emeritus.
Henry Hiram Wing, M.S. in Agr., Professor of Animal Husbandry.
Thomas Lyttleton Lyon, Ph.D., Professor of Soil Technology.
James Edward Rice, B.S.A., Professor of Poultry Husbandry.
George Walter Cavanaugh, B.S., Professor of Chemistry in its Relations to Agriculture.
George Nieman Lauman, B.S.A., Professor of Rural Economy.
Herbert Hice Whetzel, M.A., Professor of Plant Pathology.
Elmer Otterbein Fippin, B.S.A., Extension Professor of Soil Technology.*
George Frederick Warren, Ph.D., Professor of Farm Management.
William Alonzo Stocking, M.S.A., Professor of Dairy Industry.
Wilford Murry Wilson, M.D., Professor of Meteorology.
Ralph Sheldon Hosmer, B.A.S., M.F., Professor of Forestry.
James George Needham, Ph.D., Professor of Entomology and Limnology.
Rollins Adams Emerson, D.Sc., Professor of Plant Breeding.
Harry Houser Love, Ph.D., Professor of Plant Breeding.
Donald Reddick, Ph.D., Professor of Plant Pathology.
Edward Gerrard Montgomery, M.A., Professor of Farm Crops.
George Alan Works, B.Ph., M.S. in Agr., Professor of Rural Education.
Flora Rose, B.S., M.A., Professor of Home Economics.
Martha Van Rensselaer, A.B., Professor of Home Economics.
James Adrian Bizzell, Ph. D., Professor of Soil Technology.
Glenn Washington Herrick, B.S.A., Professor of Economic Entomology and Entomologist of the Experiment Station.
Howard Wait Riley, M.E., Professor of Rural Engineering.
Harold Ellis Ross, M.S.A., Professor of Dairy Industry.
Hugh Charles Troy, B.S.A., Professor of Dairy Industry.
Samuel Newton Spring, B.A., M.F., Professor of Silviculture.
Karl McKay Wiegand, B.S., Ph.D., Professor of Botany.
William Henry Chandler, M.S. in Agr., Ph.D., Professor of Pomology and Vice Director of Research.
Arthur Bernhard Recknagel, B.A., M.F., Professor of Forest Management and Utilization.
Merritt Wesley Harper, M.S., Professor of Animal Husbandry.
Cyrus Richard Crosby, A.B., Extension Professor of Entomology.
Elmer Seth Savage, M.S.A., Ph.D., Professor of Animal Husbandry.
Kenneth Carter Livermore, M.S. in Agr., Professor of Farm Management.
Edward Albert White, B.Sc., Professor of Floriculture.
Alvin Casey Beal, Ph.D., Professor of Floriculture.
Herbert Andrew Hopper, B.S.A., M.S., Extension Professor of Animal Husbandry.
Edward Sewall Guthrie, M.S. in Agr., Ph.D., Professor of Dairy Industry.
Maurice Chase Burritt, M.S. in Agr., Professor in Extension Service and Vice Director of Extension.
William Charles Baker, B.S.A., Professor of Drawing.
Mortier Franklin Barrus, Ph.D., Extension Professor of Plant Pathology.

* Absent on leave.

Lewis Josephus Cross, B.A., Ph.D., Professor of Chemistry in its Relations to Agriculture.
Oskar Augustus Johannsen, A.M., Ph.D., Professor of General Biology.
Clyde Hadley Myers, Ph.D., Professor of Plant Breeding.
Bristow Adams, B.A., Professor, Editor, and Chief of Publications.
Dick J. Crosby, M.S., Professor in Extension Service.
Asa Carlton King, B.S.A., Professor of Farm Practice.
Cornelius Betten, Ph.D., Vice Dean of Resident Instruction.
George Abram Everett, A.B., LL.B., Professor of Extension Teaching.
Lewis Knudson, B.S.A., Ph.D., Professor of Botany.
E. Gorton Davis, B.S., Professor of Landscape Art.
Ralph Wright Curtis, M.S.A., Professor of Landscape Art.
Claude Burton Hutchison, M.S. in Agr., Professor of Plant Breeding.
Ralph Waldo Rees, A.B., B.S., Extension Professor of Pomology.
Jacob Richard Schramm, A.B., Ph.D., Professor of Botany.
Harry Oliver Buckman, M.S.A., Ph.D., Professor of Soil Technology.
Ralph Hicks Wheeler, B.S., Professor in Extension Service.
William Foster Lusk, B.Ph., M.S.A., Professor of Rural Education.
Paul Work, A.B., M.S. in Agr., Acting Professor of Vegetable Crops.*
John Bentley, jr., B.S., M.F., Professor of Forest Engineering.
Paul J. Kruse, A.B., Ph.D., Professor of Rural Education.
Rolland Maclaren Stewart, A.B., Ph.D., Professor of Rural Education.
James Ernest Boyle, Ph.D., Extension Professor of Rural Economy.
Ezra Dwight Sanderson, B.S., Professor of Rural Organization.
Homer Columbus Thompson, B.S., Professor of Vegetable Gardening.
William Joseph Wright, B.S., M.S., Extension Professor of Rural Education.
Warren Simpson Thompson, A.B., A.M., Ph.D., Acting Professor of Rural Organization.
Cora Ella Binzel, Acting Professor of Rural Education.
Byron Burnett Robb, B.S. in Agr., M.S. in Agr., Professor of Rural Engineering.
Annette J. Warner, Acting Professor of Home Economics.
James Kenneth Wilson, B.S., Ph.D., Professor of Soil Technology.
Blanche Evans Hazard, A.B., M.A., Acting Professor of Home Economics.
Karl John Seulke, M.S.A., Ph.D., Professor of Animal Husbandry.
Lula Grace Graves, Professor of Home Economics.
Edmund Louis Worthen, M.S., Extension Professor of Soil Technology.
Julian Edward Butterworth, Ph.D., Professor of Rural Education.
Whitman Howard Jordan, LL.D., Professor of Animal Nutrition.†
Ulysses Prentiss Hedrick, Sc.D., Professor of Pomology.†
Lucius Lincoln Van Slyke, Ph.D., Professor of Dairy Chemistry.†
Fred Carlton Stewart, M.S., Professor of Plant Pathology.†
Percival John Parrott, M.A., Professor of Entomology.†
Robert Stanley Breed, Ph.D., Professor of Dairy Bacteriology.†
Rudolph John Anderson, Ph.D., Professor of Animal Nutrition.†
Reginald Clifton Collison, M.S., Professor of Soil Technology.†
Robert Pelton Sibley, A.B., M.A., L.H.D., Professor and Secretary.
Howard Edward Babcock, Ph.B., State Leader of County Agents.
Jay Coryell, B.S. in Agr., County Agent Leader.
Fred Eugene Robertson, B.S. in Agr., Assistant County Agent Leader.
Lewis Austin Toan, B.S. in Agr., Assistant County Agent Leader.
Thomas Everal Milliman, Assistant County Agent Leader.
Charles Arthur Taylor, Assistant County Agent Leader.
Lloyd R. Simons, B.S.A., Assistant County Agent Leader.
James Chester Bradley, Ph.D., Assistant Professor of Entomology and Curator of Invertebrate Zoology.
George Charles Embody, Ph.D., Assistant Professor of Aquiculture.
Mrs. Helen Binkerd Young, B.Arch., Assistant Professor of Home Economics.
Mrs. Anna Botsford Comstock, B.S., Assistant Professor of Nature Study.
Harry Morton Fitzpatrick, Ph.D., Assistant Professor of Plant Pathology.
Walter Warner Fisk, M.S. in Agr., Assistant Professor of Dairy Industry.
Royal Gilkey, B.S.A., Assistant Professor in Extension Service.*
Lex Ray Hesler, Ph.D., Assistant Professor of Plant Pathology.

* Absent on leave.
† By affiliation with the New York Agricultural Experiment Station at Geneva.

Earl Whitney Benjamin, B.S. in Agr., M.S. in Agr., Ph.D., Assistant Professor of Poultry Husbandry.
Arthur Johnson Eames, A.B., A.M., Ph.D., Assistant Professor of Botany.
Robert Matheson, M.S. in Agr., Ph.D., Assistant Professor of Economic Entomology and Assistant Entomologist of the Experiment Station.
David Lumsden, Assistant Professor of Floriculture.
John Hall Barron, B.S.A., Assistant Extension Professor of Farm Crops.
Gad Parker Scoville, B.S. in Agr., Assistant Extension Professor of Farm Management.
Arthur Augustus Allen, Ph.D., Assistant Professor of Ornithology.
Leonard Amby Maynard, A.B., Ph.D., Assistant Professor of Animal Husbandry.
Forest Milo Blodgett, Ph.D., Assistant Extension Professor of Plant Pathology.
Frank Elmore Rice, A.B., Ph.D., Assistant Professor of Chemistry in its Relations to Agriculture.
Lester Wayland Sharp, B.S., Ph.D., Assistant Professor of Botany.
John Clarence McCurdy, B.S., C.E., Assistant Professor of Rural Engineering.
Clarence A. Boutelle, Assistant Extension Professor of Animal Husbandry.
Charles Howard Royce, M.S.A., Assistant Extension Professor of Animal Husbandry.
George Harris Collingwood, B.S., A.M., Assistant Extension Professor of Forestry.
Montgomery Robinson, Litt.B., B.S., Assistant Professor in Extension Service.
Otis Freeman Curtis, A.B., Ph.D., Assistant Professor of Botany.
Thomas Joseph McInerney, M.S. in Agr., Assistant Professor of Dairy Industry.
Eugene Davis Montillon, B.Arch., Assistant Professor of Landscape Art.
Juan Estevan Reyna, E.E., Assistant Professor of Rural Engineering.
Arthur John Heinicke, B.S.A., M.A., Ph.D., Assistant Professor of Pomology.
Olney Brown Kent, B.S., Ph.D., Assistant Professor of Poultry Husbandry.
Henry William Schneck, B.S., M.S.A., Assistant Professor of Vegetable Gardening.
Louis Melville Massey, A.B., Ph.D., Assistant Professor of Plant Pathology.
Beulah Blackmore, B.S., Assistant Professor of Home Economics.
Bernard Albert Chandler, B.S., M.F., Assistant Professor of Forest Utilization.
Edward Gardner Misner, B.S., Ph.D., Assistant Professor of Farm Management.
Mary Frances Henry, A.B., Assistant Professor of Home Economics.
Sarah Lucile Brewer, B.S., Assistant Extension Professor of Home Economics.
Helen Canon, B.A., B.S., Assistant Extension Professor of Home Economics.
Warren Kendall Blodgett, 2d, A.B., Assistant Extension Professor of Rural Engineering.
Mark Joseph Smith, B.S., Assistant Extension Professor of Animal Husbandry.
John Haring Voorhees, B.S., Assistant Extension Professor of Farm Crops.
Helen Monsch, B.S., M.A., Assistant Professor of Home Economics.
William Irving Myers, B.S., Ph.D., Assistant Professor of Farm Management.
Gustave Frederick Heuser, B.S., M.S. in Agr., Ph.D., Assistant Professor of Poultry Husbandry.
Earle Volcart Hardenburg, B.S., M.S. in Agr., Ph.D., Assistant Professor of Farm Crops.
James Lewis Strahan, B.S. in Agr., M.S. in Agr., Assistant Professor of Rural Engineering.
Allan Cameron Fraser, B.S., Ph.D., Assistant Professor of Plant Breeding.
Claribel Nye, B.S., Assistant Extension Professor of Home Economics.
Peter Walter Claassen, M.A., Ph.D., Assistant Professor of Biology.
Roy Glen Wiggans, B.S.A., M.S.A., Assistant Professor of Farm Crops.
Charles Chupp, A.B., Ph.D., Assistant Extension Professor of Plant Pathology.
Frank Pores Bussell, B.A., Ph.D., Assistant Professor of Plant Breeding.
Benjamin Dunbar Wilson, B.S., M.S., Ph.D., Assistant Professor of Soil Technology.
Nancy Hill McNeal, Ph.B., Assistant Extension Professor of Home Economics.
Emery N. Ferriss, Ph.B., Ph.D., Acting Assistant Professor of Rural Education.
Laurence Howland MacDaniels, A.B., Ph.D., Assistant Professor of Pomology.
E. Laurence Palmer, A.B., M.A., Ph.D., Assistant Professor of Rural Education.
Bonnie Elizabeth Scholes, B.S., M.A., Assistant Extension Professor of Home Economics.
James Duncan Brew, B.S., Assistant Extension Professor of Dairy Industry.
Frederick Gardner Behrends, B.S., Assistant Extension Professor of Rural Engineering.
Robert Morrill Adams, B.S., A.B., Assistant Extension Professor of Vegetable Gardening.
Harry Wilmer Dye, B.S.A., M.S.A., Ph.D., Assistant Professor of Plant Pathology.
Emma Johnson, B.S. in Agr., Assistant State Leader of Junior Extension.
Florence H. Freer, B.S., State Home Demonstration Leader.

Esther L. Snook, B.S., Assistant State Home Demonstration Leader.
Mrs. Ruby Green Smith, A.B., A.M., Ph.D., Assistant State Home Demonstration Leader.
George Walter Tailby, jr., B.S.A., Instructor and Stockman in Animal Husbandry.
John Thomas Lloyd, A.B., Instructor in Limnology.
Richard Alan Mordoff, B.S. in Agr., A.M., Instructor in Meteorology.
Oliver Wesley Dynes, B.S., M.S. in Agr., Instructor in Farm Crops.
Cass Ward Whitney, B.S., Instructor in Extension Service.
Lua Alice Minns, B.S., M.S. in Agr., Instructor in Floriculture.
Winifred Enos Ayres, Extension Instructor in Dairy Industry.
Clark Leonard Thayer, B.Sc., Instructor in Floriculture.
Lewis Merwin Hurd, Extension Instructor in Poultry Husbandry.
Cedric Hay Guise, B.S., M.F., Instructor in Forestry.
Albert Reiff Bechtel, B.S., A.M., Instructor in Botany.
James Marshall Brannon, B.A., M.A., Instructor in Botany.
Frank Burkett Wann, A.B., Instructor in Botany.
Clara Louise Garrett, B.S., Instructor in Drawing.
Clarence Vernon Noble, B.S., Instructor in Farm Management.
Walter Gernet Krum, Extension Instructor in Poultry Husbandry.
Howard Campbell Jackson, B.S., M.S. in Agr., Instructor in Dairy Industry.
Julia Gleason, Instructor in Home Economics.
Winifred Moses, B.S., Instructor in Home Economics.
Edwina Maria Smiley, A.B., Instructor in Plant Pathology.
George Clayton Dutton, Extension Instructor in Dairy Industry.
Roy Lewis Gillett, B.S., Instructor in Farm Management.
Mrs. Jessie Austin Boys, B.S., Instructor in Home Economics.
Laurence Joseph Norton, B.S., Extension Instructor in Farm Management.
Gertrude Elizabeth Douglas, A.B., A.M., Ph.D., Instructor in Botany.
Ralph Simpson Nanz, B.S., Instructor in Botany.
William Alonzo Whiting, B.S., Instructor in Dairy Industry.
Gladys Elizabeth Smith, B.S., Instructor in Home Economics.
Frances Remington Kelley, B.A., Instructor in Home Economics.
Walter Sprague Frost, B.S., Extension Instructor in Agricultural Chemical Analysis.
Joseph Pullman Porter, B.S., Extension Instructor in Landscape Art.
Lawrence Paul Wehrle, B.S., M.S., Extension Instructor in Entomology.
Ernest Charles Young, B.S., Extension Instructor in Farm Management.
Charles Loring Allen, B.A., M.S. in Agr., Instructor in Animal Husbandry.
Walter Housley Wellhouse, M.A., Instructor in Entomology.
Frank Latta Fairbanks, M.E., Instructor in Rural Engineering.
Roy A. Olney, B.S., Instructor in Rural Education.
Joseph Brackin Kirkland, B.S., Instructor in Farm Practice.
John Churchill Maddy, B.S., Extension Instructor in Animal Husbandry.
Juliette Norma Anderson, B.S., Instructor in Plant Pathology.
Erford Lynn Banner, B.S., M.S., Instructor in Poultry Husbandry.
Harold Eugene Botsford, B.S., Extension Instructor in Poultry Husbandry.
Louis Michael Roehl, Instructor and Supervisor of Farm Shop Work.
William Prindle Alexander, Instructor in Natural History.
Charles Robert Stevenson, B.S., Extension Instructor in Plant Pathology.
Carl Frederick William Meusebeck, B.S., Instructor in Parasitology.
Ernest Gustaf Anderson, B.Sc., Instructor in Plant Breeding.
Theresa Elizabeth Schindler, B.A., Instructor in Floriculture.
Harry Pestana Young, B.S., Instructor in Farm Management.
William Trowbridge Merrifield Forbes, Ph.D., Assistant Curator of Lepidoptera.
Maude Sanford, B.S., Instructor in Home Economics.
Paul Andrew Downs, B.S., Instructor in Dairy Industry.
Ivan Wright, A.B., M.S., Instructor in Rural Economy.
Robert Carroll Ogle, Extension Instructor in Poultry Husbandry.
Earl Gibson Lukens, A.B., Instructor in Animal Husbandry.
Mosher Dwen Butler, B.S., Extension Instructor in Vegetable Gardening.
Warren B. Meixner, B.S., Instructor in Landscape Art.
Leslie Ellsworth Card, B.S., Instructor in Poultry Husbandry.
Frances Beatrice Hunter, B.S., Instructor in Home Economics and Supervisor of Shop Work.

Carl George Vinson, B.S., Extension Instructor in Pomology.
Alice May Blinn, B.S., Extension Instructor in Home Economics.
Raymond Arnold Perry, B.S., Instructor in Dairy Industry.
Claude Willard Leister, B.S., Instructor in Ornithology.
William Henry Eyster, A.B., A.M., Instructor in Botany.
Walter Conrad Muenscher, A.M., Instructor in Botany.
John D. Detweiler, B.A., M.A., Instructor in Entomology.
Florence Ethel Axtell, B.S., Instructor in Rural Education.
Leon Augustus Hausman, A.B., A.M., Ph.D., Instructor in Biology.
Francis Coe Smith, B.S., Extension Instructor in Farm Crops.
Jay John Grimm, B.S., Instructor in Botany.
Lolita Evelyn Healey, A.B., Instructor in Home Economics.
Charles Orchard Smith, B.S., Extension Instructor in Vegetable Gardening.
Flora Martha Thurston, B.S., Extension Instructor in Home Economics.
Edith Sara Ranney, B.S., Extension Instructor in Home Economics.
Mathilda Emilie Bertrams, Ph.B., Extension Instructor in Home Economics.
Mortimer Demarest Leonard, B.S., Extension Instructor in Entomology.
Ruth E. Chipman, A.B., M.A., Extension Instructor in Agricultural Chemistry.
Ada Eljiva Georgia, Assistant in Natural History.
Emmons William Leland, B.S.A., Superintendent of Field Experiments in Soil Technology.
Charles Edward Hunn, Assistant in Plant Propagation.
William Thomas Craig, Assistant in Plant Breeding Investigations.
Walton I. Fisher, Assistant in Plant Breeding Investigations.
Harold Haydn Clum, A.B., Assistant in Botany.
Ernest Dorsey, B.S., Assistant in Plant Breeding.
Thomas Lysons Martin, B.A., Assistant in Soil Technology.
Eleanor Hillhouse, B.S., Assistant in Home Economics.
Gordon Kennedy Middleton, B.S., Assistant in Farm Crops.
Rodney Wesson Pease, Assistant in Extension Service.
Fannie Coolbaugh Rane, A.B., Assistant in Botany.
Catharine Elizabeth Koch, B.S., M.A., Assistant in Plant Propagation.
Lewis Arthur Eyster, B.A., Assistant in Plant Breeding.
Mildred E. Stratton, B.A., Assistant in Botany.
Helen Alice Purdy, A.B., Assistant in Plant Pathology.
Helen Elizabeth Murphy, B.S., Assistant in Biology.
Henry Edward Schradieck, B.S., Assistant in Aquiculture.
Howard Bushnell Allen, B.S., Assistant in Junior Extension.
Lowell Fitz Randolph, Ph.B., Assistant in Botany.
Fred Albert Carlson, B.S., Assistant in Soil Technology.
Hazel Elizabeth Branch, A.B., M.A., Assistant in Biology.
Alexander McTaggart, B.S.A., Assistant in Soil Technology.
Charles Jay Settle, jr., B.S., Assistant in Farm Practice.
Fred Poos, jr., A.B., A.M., Assistant in Biology.
John Levenus Buys, B.S., Assistant in Entomology.
Carl Louis Wilson, A.B., Assistant in Botany.
B. B. Maticka, Assistant in Botany.
Mary Isabelle Potter, B.S., M.L.D., Assistant in Landscape Art.
Bernard Bellis, B.S., Assistant in Agricultural Chemistry.
Ellen Edmonson, A.B., Assistant in Entomology.
Frank Waldo Lathrop, A.B., M.S.A., Assistant in Rural Education.
William Seltzer, B.S., Assistant in Soil Survey.
John Samuel Everett, B.S., Assistant in Forestry.
Dane Lewis Baldwin, A.B., M.A., Secretary to Dean and Director.
Olin Whitney Smith, B.S., Assistant Registrar.
Willard Waldo Ellis, A.B., LL.B., Librarian.
George Wilson Parker, Executive Assistant.

ACTING PRESIDENT'S LETTER OF TRANSMITTAL

June 30, 1920

The Governor of the State of New York,
Albany, New York.

The Secretary of the Treasury,
Washington, D. C.

The Secretary of Agriculture,
Washington, D. C.

The Commissioner of Agriculture,
Albany, New York.

The Act of Congress, approved March 2, 1887, establishing Agricultural College Experiment Stations in connection with the Land Grant Colleges, contains the following provision: "It shall be the duty of each of said stations, annually, on or before the first day of February, to make to the Governor of the State or Territory in which it is located, a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States."

And the Act of the Legislature of the State of New York, approved April 12, 1906, providing for the administration of the New York State College of Agriculture at Cornell University, contains the following provision: "The said University shall expend such moneys and use such property of the State in administering said College of Agriculture as above provided, and shall report to the Commissioner of Agriculture in each year on or before the first day of December, a detailed statement of such expenditures and of the general operations of the said College of Agriculture for the year ending the thirtieth day of September then next preceding."

In conformity with these laws I have the honor to submit herewith on behalf of Cornell University the report for the year 1919–20 of the New York State College of Agriculture, signed by the Dean of that College, Albert R. Mann.

Dean Mann's report is so detailed and so complete that it seems unnecessary for me to do more than transmit it to you, as I hereby do.

Respectfully submitted,

ALBERT W. SMITH,
Acting President of Cornell University.

REPORT OF THE NEW YORK STATE COLLEGE OF AGRICULTURE, 1919-20

June 30, 1920

To the Acting President of the University:

Sir: I have the honor to submit herewith a report of the work of the New York State College of Agriculture for the academic year 1919-20.

The legislative program

The problem that demanded major attention during the year just closing was the necessity for relief for the College in the way of more adequate compensation of teachers, freedom from the stifling effects of the minutely segregated appropriation act which the State has employed during recent years, and provision for housing the work of the College more nearly in accordance with its requirements. All of these matters have been discussed at length in previous reports of the Dean of the College, and I am happy to be able to record at this time substantial progress in them all.

On November 30, 1918, the Dean presented to the Agricultural College Council a detailed report of the needs of the College for additional buildings, reviewing the requirements of each department in turn, and recommended that steps be taken to prepare a plan for the enlargement of the college plant in accordance with the expressed needs of the departments. Specifically it was proposed that the Council should appoint a committee of three of its members to cooperate with the President and the Dean in investigating the building requirements of the College; to visit, as might be needful, other agricultural colleges in order to study types of buildings for particular purposes; to prepare for the consideration of the Trustees a statement and description of the buildings that should be provided; to request the Committee on Buildings and Grounds to prepare a plan for the location of the buildings; to invite the State Architect to prepare preliminary plans as a basis for requesting state appropriations; and to devise ways and means for presenting the needs to the Legislature, looking toward the adoption of the entire plan by the Legislature with a view to obtaining early authorization to begin construction on several buildings and consecutive provision for the remaining needs. In this report confidence was expressed that "we shall have the earnest support of farmers of the State in presenting our needs to the Legislature." The Council approved the proposal that a plan of enlargement be developed. It did not appoint the committee requested, but instructed the Dean to make the studies and prepare tentative plans for definite consideration by the Council.

It is of interest to record here also that the Chairmen of the Joint Legislative Budget Committees subsequently requested the Dean, in February of 1919, to prepare a comprehensive plan for the further development of the College for their consideration at the 1920 session of the Legislature.

Acting on these commissions, active steps were taken to make an exhaustive study of the building requirements. The departments of the College were requested to consider their needs with great thoroughness. This they were glad to do, and their careful work provided the basis on which all subsequent plans were developed.

It soon became apparent that in considering the future demands to be made on the College it was highly desirable, if, indeed, not imperative, to learn what the progressive farmers and others interested in the rural affairs of the State wanted the College to do and to become, so that the final decisions might combine the best judgments of the staff and of the persons who are naturally most concerned in the work and the facilities of the institution. Accordingly, and after consultation with several of the most active farm leaders in the State, it was determined to invite a large number of farmers to come to the College, in groups, at their own expense, to study in detail the work and the needs of the several departments. The persons to be invited were nominated by the heads of several of the larger farmers' organizations, editors of agricultural papers, members of the college staff, and others. The names were assorted so as to bring together in a single group, or committee, persons especially interested in the work of a particular department. In all, twenty-four groups, or committees, including a few more than three hundred persons, were invited to come at various times during the months of October and November of 1919. Nearly half of those invited found it possible to come.

The committees, on their arrival, were asked to make a thorough study of the work of the departments to which they were assigned, including a review of the courses of instruction, the experimental and research work, and the extension activities, as well as buildings and facilities, and to offer suggestions for improvements. Each committee was asked to make a written report with recommendations, which was done. The combined reports constitute a very valuable and unique body of suggestions for the development of the institution.

Because of the time required — one or two days — to study the work of a department, each committee could study but a single department. In order that the final recommendations might be considered from the standpoint of the College as a whole, each departmental committee was asked to designate two of its members to return to a joint conference on

December 5. The interest of farmers in the undertaking is nowhere better revealed than by the fact that the meeting on December 5 was attended by an almost complete representation of delegates, these men and women again coming at their own expense.

The committees of farmers were not asked to consider the question of salaries of teachers, although this had become by far the most serious and acute problem affecting the College. Their studies, however, soon revealed losses, actual and threatened, from the staff, and many of the departmental committees called attention to the urgent necessity that a new and higher salary scale be established.

The meeting on December 5, after a full day of deliberation, adopted the following recommendations:

1. That the building program as outlined in the Summary of Recommendations herewith attached and made a part of this report, be approved and adopted as the program to be presented to the Legislature. (This program enumerates the buildings required, estimated to cost at present prices more than $5,000,000.)
2. That the Legislature be asked to appropriate in 1920 the sum of $2,000,000 to start three large buildings in the following order: Plant Industry, Rural Engineering, Dairy Industry; and that any part of this appropriation not needed for the above-named buildings should be available for other buildings most urgently needed.
3. That the Legislature during the session of 1920 be asked to authorize the drawing of plans to cover the remainder of the program as recommended, and that the Legislature be asked in 1921 to appropriate funds to start all other buildings provided for in the committee recommendations.
4. That the "budget system" be changed so that, while the proposed expenditures shall be itemized in detail, appropriations shall be made under general classifications only, such as (1) personal service, (2) maintenance, and (3) repairs and replacements; that the administrative officers in charge of the institution be given the power of distributing the available funds granted under these general heads; and that this recommendation apply to all state educational institutions.
5. That the Dean of the New York State College of Agriculture be further relieved of detailed administrative duties, and to that end that a vice-deanship of resident teaching and a vice-directorship of research work be created, with minimum salaries of $6000 for such positions.
6. That a salary of $10,000 be provided for the Dean.
7. That the following salary scale be recommended as a minimum: for heads of departments, $5000; for full professors, $4000; for assistant professors, $2500; for instructors, $1500; for assistants, $800; for stenographers, $900.
8. That, whereas the small increase asked for by Dean Mann in the budget for 1920–21 will be wholly inadequate and will furnish no relief such as we desire, the salary estimates submitted by Dean Mann for the fiscal year beginning July 1, 1920, be revised in accordance with the minimum scale heretofore recommended, and that the changes in the

salary scale recommended by the Committee become effective for the fiscal year beginning July 1, 1920.

9. That the staff of the college be developed to meet the expansion approved by the several committees which have made studies of the needs of respective departments, and that the executive committee of this general committee make more detailed and specific studies and recommendations toward developing the work of the respective departments and toward adequate funds for maintenance.

10. That the executive committee submit to the various members who have attended the conferences at the College the recommendations of the general committee for their individual approval and signature.

11. That the executive committee take immediate steps to place the recommendations and conclusions of this conference on the needs of the College before the Agricultural Conference Board and before the leaders of all the farm organizations in New York State, and that such other steps be taken as are necessary to acquaint their various subordinate organizations or local branches with the recommendations of this conference as to the needs of the College.

12. That the executive committee and the Dean invite the press of the State to visit the College and study its service to the people of the State and its needs.

13. That the executive committee ask a subordinate committee consisting of one member of the faculty group and one representing farmers, to formulate a statement as to what the College of Agriculture means to the agriculture of the State.

14. That in working out these plans, special emphasis be placed on acquainting the consumers of the State with the value of the College to them.

The conference appcinted a committee to carry out its recommendations. This committee reported to the Agricultural Conference Board on December 22, when the findings and recommendations of the conference of December 5 were unanimously approved and there was created a "Farmers' Joint Committee for the Promotion of Education in Agriculture and Home Economics in the State of New York" consisting of the following persons: William A. Mather, Chairman, Adams; E. R. Eastman, Executive Secretary, 303 Fifth Avenue, New York; James Fear, Recording Secretary, Holland Patent; Mrs. Lewis Seymour, 105 North Street, Binghamton; F. A. Salisbury, Phelps; C. F. Mason, Williamson; Daniel Dean, Nichols; State Horticultural Society, E. C. Gillette, Penn Yan; Dairymen's Association, H. C. Troy, Ithaca; State Grange, W. N. Giles, Skaneateles; Farm Bureau Federation, S. L. Strivings, Castile; Home Bureau Federation, Mrs. A. E. Brigden, Cortland; Dairymen's League, Inc., R. D. Cooper, New York; State Agricultural Society, C. F. Boshart, Lowville.

This committee, individually and collectively, has actively sponsored the cause of the College before the people of the State and the Legislature,

and large credit is due to its members, and to the great body of farmers who supported them and whom they represent, for the successful outcome of the legislative effort. The College of Agriculture and the people of the State are alike indebted to them for their public service ably discharged. The College belongs to the people of the State. They established it as a state institution, and they have ever come to its support in its times of special need. The College is deeply sensible of its increased responsibility for efficient, productive service to the State which the renewed expression of confidence and larger provision for its needs impose.

On December 20 the Agricultural College Council met to consider the recommendations of the Dean for the development of the College, these recommendations being substantially the program which was put forward by the farmers' committee and which represented the best judgment of the staff and of those who had studied the institution. The Council voted to " approve in principle the findings of the [farmers'] conference and concur in the larger conception of the importance and the requirements of the College." The Council made its recommendations in detail to the Board of Trustees, which affirmed these recommendations on January 3, 1920, for transmission to the Legislature. The result is that the Appropriation Act passed by the Legislature and approved by the Governor carries the following items for the State College of Agriculture:

1. For regular maintenance for the year 1920–21, $1,270,888.80, an increase of $260,170 over the appropriation for the year 1919–20. Of this increase nearly three-fourths is to be applied to increases in salaries of the staff. While these increases will still leave us considerably below the minimum scale recommended by the farmers' committee and concurred in by the Trustees, they afford very substantial relief to a deserving and grateful faculty.

2. Salary provision for a vice dean of resident instruction, a vice director of research, three new professorships in agricultural economics and farm management, a new professorship in plant pathology, and three additional assistant professorships in home economics.

3. For new construction, a special provision: " To further the development of the State College of Agriculture, Cornell University, providing for its extension through a plan to be approved by the Trustees of said University, by or before December 1, 1920, an authorization of three million dollars ($3,000,000) is hereby made. The State Architect may employ such experts and other assistants as may be necessary for the proper development of plans, soil surveys, test pits, test borings, and conduct of such work, and their compensation shall be fixed by him and paid from appropriation made herewith, with the approval of the Trustees

of Cornell University. For the purpose of commencing such work, the sum of five hundred thousand dollars ($500,000) is hereby appropriated."

The bill carries also a separate appropriation of $17,000 for beginning the construction of a cold storage plant.

The appropriations for salaries of the teaching staff are combined for the several grades, heads of departments, professors, assistant professors, instructors, and assistants, in such a way as to allow the authorities discretion in fixing the salaries of individuals within these groups, except that a prescribed maximum salary and maximum number of appointees within each group shall not be exceeded. This departure from the narrow segregation which has obtained heretofore will afford a welcome measure of relief. It is to be regretted that there continues to be no administrative freedom or discretion in the adjustment of salaries of employees other than teachers.

The results of the legislative program as a whole have been successful and gratifying beyond our early expectations. With the many pressing demands made on the Legislature and the Governor for the maintenance and enlargement of the State's varied activities, the treatment accorded our requests this year has been notably generous. The sympathetic interest and appreciation of our requirements by Henry M. Sage, Chairman of the Senate Finance Committee, H. Edmund Machold, Chairman of the Assembly Ways and Means Committee, and Lewis F. Pilcher, State Architect, all of whom made special studies of the needs of the College by personal visits, and by Governor Alfred E. Smith, who approved all of the items submitted to him by the Legislature, made possible the accomplishment of the undertaking. Grateful acknowledgment is made to them. I desire also to record appreciation, on behalf of myself and my associates in the College, of the constant helpfulness of the President and members of the Board of Trustees throughout the entire course of our efforts.

Mention should be made of two other bills passed by the Legislature late in the session and approved by the Governor. One provides $2700 for the erection of two sheds ($1350 each) on the outlying experimental field plats at Churchville, in Monroe County, and at Alfred, in Allegany County. The second commissions the College to inaugurate special extension work in agriculture and home economics among the Indian wards on the reservations within the State. It carries an appropriation of $10,000, which may be used, aside from the maintenance of general extension activities on the reservations, for the payment of scholarships, living expenses, and books for Indian men and women in short courses at the State College of Agriculture, the payment of travel expenses of specially chosen Indians for Farmers' Week and similar occasions, and as a rotary

loan fund to Indian farmers for the purchase of seeds, tools, and stock. In the organization of this new enterprise, the College has had the benefit of the services of Dr. Erl Bates, of Syracuse, whose years of active service in behalf of the Indians has placed him in the confidence of the tribes and has given him an exceptional grasp of their problems and means of solution. This work, the importance of which has been fully demonstrated, should be made permanent.

The proposed college of home economics

The teaching of home economics had its inception at Cornell University in the year 1900, when Miss Martha Van Rensselaer was appointed to initiate special work on the problems of farm women. Her first undertaking was the establishment of a reading course, which within less than one year attained an enrollment of six thousand readers. From this beginning the work has gradually expanded. In 1904, when the State established the College of Agriculture at Cornell University as the New York State College of Agriculture, it assumed responsibility for the promotion of the activities of the College, including the work in home economics. By 1907 this work had attained such proportions that the Trustees recognized it as a separate department in the College. In 1911 the State appropriated $154,000 to provide a special building for housing the department. On September 20, 1919, the Trustees designated the department as the School of Home Economics in the State College of Agriculture, this action being taken in recognition of the rapidly increasing importance, scope, and specialization of the work, and the fact that the department had become practically a self-contained professional school; and in the request made by the Trustees to the Legislature at that meeting, the Legislature was urged to complete the school in buildings and staff as rapidly as possible.

The logical outcome of the growth of the work in home economics and the distinctive recognition coming to it, was the action of the Board of Trustees on January 3, 1920, requesting the Legislature to establish the school as a separate State College of Home Economics. Subsequently bills were introduced in both houses of the Legislature to accomplish the change. The bill passed the Assembly but was held in committee in the Senate. This was not altogether unexpected, as time is required to effect an appreciation of the larger importance of the field of home economics in state welfare. The bill will ultimately pass. It is inevitable that this field of special interest to women, with its own body of knowledge and range of activity, will be given the recognition which it deserves. The proposal at once received the indorsement of women's organizations and of thousands of individual women throughout the State.

The change proposed is little more than a change in name and in administration. The main lines of work in a professional college of home economics have already been provided by state appropriation. Such additions to the staff and to buildings and facilities as the work calls for will be required to take care of its normal growth, whether it is recognized as a separate college or continues as a school in its present relationship. The State will derive greater profit from the work which it has already established here when it gives to that work the larger recognition which will result from the change in name.

Affiliation with the New York Agricultural Experiment Station

One of the most gratifying and promising events of the past year has been the affiliation effected between the State College of Agriculture and the New York Agricultural Experiment Station at Geneva. The formal act of affiliation was the consummation of a discussion between the institutions extending over several years. The bond that has been established did not involve legislative authorization, but was effected on the basis of the powers which the authorities of the two institutions now have under the law. On February 14, 1920, the Committee on General Administration of the Board of Trustees of Cornell University took the following action:

Resolved, That the acceptance by members of the staff of the College of Agriculture of appointments to the staff of the New York State Experiment Station at Geneva, without pay and without required duties, is hereby approved, the members of the staff so appointed to be those mutually agreed upon by the Director of the Station and the Dean of the College of Agriculture.

Resolved, That the President is hereby authorized to nominate for appointment to the staff of the New York State College of Agriculture such members of the staff of the New York State Experiment Station at Geneva, without pay and without required duties, as may be mutually agreed upon by the Director of the Station and the Dean of the College of Agriculture.

Similar action had been taken by the Board of Control of the State Experiment Station a short time before.

Under the new arrangement each of the institutions will maintain its present organization and functions and no change will be involved in the status of the men affected in their respective institutions. The affiliation will promote the interests of both, which at times are closely parallel, and will make possible an exchange of work and workers between the two institutions. It will be possible for the staff of the College of Agriculture to have access to the materials and laboratories of the State Experiment Station, and the investigators at the Station can take advantage of the facilities at Ithaca. Conferences will be promoted between the workers at the two institutions, resulting both in a better mutual understanding of the work in progress at the two places and in the removal

of the likelihood of any unnecessary overlapping. It is hoped also that the arrangement will be advantageous to graduate students who may be connected with either institution.

While under the law both institutions are required to conduct investigations and research, and both have maintained some extension work, the relations between the institutions have been notably harmonious and cordial, and the affiliation has been mutually desired. The more intimate relationship now officially established promises an increasingly pleasant and beneficial association in future. The step is an important one in the furtherance of the State's program for the promotion of education and research in agriculture.

The members of the State Experiment Station staff who have been appointed to professorships in the College of Agriculture at Cornell University are: Dr. U. P. Hedrick, professor of pomology; Dr. L. L. VanSlyke, professor of dairy chemistry; F. C. Stewart, professor of plant pathology; P. J. Parrott, professor of entomology; Dr. R. S. Breed, professor of dairy bacteriology; R. J. Anderson, professor of animal nutrition; R. C. Collison, professor of soil technology; Dr. W. H. Jordan, professor of animal nutrition.

Members of the State College who have been appointed to places on the staff of the Experiment Station are: Dr. T. L. Lyon, chemist, Division of Agronomy; Dr. R. A. Emerson, geneticist, Division of Horticulture; W. A. Stocking, bacteriologist, Division of Bacteriology; Dr. L. A. Maynard, biochemist, Division of Biochemistry; G. W. Herrick, entomologist, Division of Entomology; Dr. Donald Reddick, botanist, Division of Botany; A. R. Mann, Agricultural Economics.

Increasing importance of economics

For many years the chief activities of the agricultural colleges and experiment stations have been concerned with problems of plant and animal production. With the enormous actual and relative increase in city populations, rapid changes have come. The problems of plant and animal growth are more important than formerly, but are no longer the only questions with which agricultural education and research are concerned. The rapid growth of cities and the relatively slow increase in numbers of persons engaged in agriculture means that the food production of each agricultural worker must be much greater than heretofore. With these changes, new problems of business methods on the farm, financing of farm operations, transportation and marketing of products, and the maintenance of satisfactory living conditions on farms, have arisen.

Now that agriculture is more of a business and less of a self-sufficient home industry, the problems of business organization and management

of farms are of the utmost importance. For many years this College has been doing extensive work in studying and teaching methods of farm organization and management. The data on costs of production of various farm products and on living conditions on farms have been of service to price commissions. The State Census of Agriculture tabulated by the former Department of Farm Management, and data obtained in cooperation with the United States Bureau of Crop Estimates on labor, housing, and living conditions on farms, have all helped to direct public activities related to agriculture. They have also aided in stabilizing conditions on farms. The price studies have been of help in steadying production. Studies are now being made of farm labor, the movements of farm population, the standards and the costs of living on farms, and the combination of agriculture and factory work for industrial employees.

Many persons leave the farms because they do not see the means of engaging profitably in farming without capital. Some studies have been made of the means by which such persons may acquire the necessary capital and credit. The means by which credit agencies may furnish the necessary capital for agriculture require study. Recognizing these needs, the 1920 Legislature provided a professorship in farm finance.

The large and constantly increasing quantities of food that must be moved over our roads, railroads, and waterways have created many new problems in transportation. A professorship in transportation has been provided for next year.

So many economies can be made by assembling business for quantity buying and selling that the organization of cooperative associations of farmers has been very rapid in recent years. The determination of the best methods for the formation and management of such associations and the dissemination of this knowledge is one of the important duties of the College. The wool auctions, the central packing houses for fruit, cooperative purchases of stock feed, and cooperative ownership of milk plants, are among the important developments in this field. Perhaps no problem is today arousing more controversy and causing deeper concern than the problem of distribution of food. Improvement in the methods of distribution to keep pace with the growth and congestion of population is one of the outstanding needs of the near future. A new professorship of marketing has been established for next year.

All this work in the College is now centered in the Department of Agricultural Economics and Farm Management, a combination of the former departments of Farm Management and Rural Economy effected by the Trustees on September 20, 1919. For the present and immediate future a large part of the work of this department must be given to inves-

tigation, in which results come slowly. Much has already been done. There are large numbers of regular and winter-course students seeking instruction in these subjects, and extension teaching among farmers has reached considerable proportions in response to insistent demands. As an indication of the importance attached to the work it may be pointed out that thirty-one graduate students from this and other countries are now registered for special study in the Department of Agricultural Economics and Farm Management.

The social phase of country life

It is becoming increasingly apparent that the problems of agriculture are not solely those of the technique of production and distribution. Agriculture is at once a vocation and a mode of life. If the farm enterprise is to have permanent success, life must be satisfying to the farm family. More economic production and more profitable prices for farm products are essential, but economic prosperity will not of itself make the life of the rural community fully satisfying. Many of the material advantages of the city can be purchased by farmers if they have more adequate incomes; but the superior opportunities offered in the cities for recreation, education, and social and religious life will continue to draw an undue proportion of the more ambitious from farms and villages until the rural community is so organized that it can compete with the city in the matter of attractions. The social problems of country life cannot be longer neglected if we are to maintain the best type of American citizenship on our farms.

Our new understanding of human nature and of society has been developed by the sciences of psychology and sociology chiefly with regard to life under urban conditions; but the use of the methods of these sciences in the study of rural life reveals parallel series of rural social problems challenging the best scientific ability. Indeed, it seems probable that thorough scientific study of the structure and process of rural society, representing the type of social organization under which the mass of mankind has lived from the dawn of civilization, may do much to reveal principles of social behavior which are essential to the solution of the problems of our more highly complex urban society. The increased contact of rural dwellers with cities, better communication within rural communities, and the more general reading of the press and periodical literature, are arousing the interest of these people in rural social conditions. Having received assistance from the College of Agriculture in their problems of production, the people of the open country now look to it for assistance in solving those of social organization. We are as yet meagerly equipped to meet these needs but have made a good beginning.

The chief effort of the Department of Rural Social Organization in the College at the present time is to give some fundamental training in the social problems of rural communities to undergraduate students, very many of whom will go into positions of leadership where they can educate public opinion to the importance of these problems and can arouse interest which will result in community progress. The demand for trained teachers and leaders in rural sociology and rural social work greatly exceeds the supply. Because of its pioneer work in the country life movement, Cornell University is expected to take a place in this new field, and it is hoped that strong courses for graduate students seeking to fit themselves for these positions may be developed.

The scientific study of rural social problems is but begun, and is now developing methods and inventing technique. Investigations in this field is slow and costly, being largely dependent at the present stage on the survey method and requiring a considerable volume of data before interpretation can be attempted. With the present unrest among the industrial and agricultural classes, it is of the highest importance that such investigations be pushed as rapidly as possible so that we may have some measure of scientific information as a guide for shaping social policy. There is already an urgent demand that immediate assistance be given to rural communities in planning such enterprises as community buildings, church surveys, recreation programs, and community organization.

This demand should be met without neglecting the more fundamental work of investigation. Without such a practical testing of the principles of rural social science so far tentatively stated, there can be no real proof of their validity, so that permanent advance in this field must always depend on the opportunity for successful application of the principles advanced. The College needs, and has requested of the Legislature, additional teachers for both the resident and the extension phases of the work. The fullest development of the teaching of the sociology of country life in this College will be conditioned on the recognition given to fundamental courses in sociology in the College of Arts and Sciences.

The rural education phase

Since the passage of the Federal Vocational Educational Act in 1917, funds from state and federal sources have made possible a considerable development of the Department of Rural Education. The regulations governing the expenditure of the funds provided for under the Vocational Act, however, make it necessary for the department to limit its instructional work to prospective teachers of vocational agriculture and home economics. This condition needs to be remedied by a proportionately larger appropriation of state funds so that we may meet the demands of a considerable

number of students who each year desire professional work but who wish to enter other phases of teaching than those of vocational agriculture and homemaking.

A larger responsibility than this, however, is before the College. Aside from its extension activities, which center in the Cornell Rural School Leaflet and the junior extension work, the Department of Rural Education has little contact with the problems of elementary education in the rural communities of the State. Both of the aforementioned activities are proving their worth, but the scope of the department needs to be broadened so as to relate its work to both the elementary and the secondary schools of the rural sections of the State if we are to make our full contribution to rural education.

The importance of this was forcibly brought to the College during the last Farmers' Week, when the State Conference of Farm Organizations passed a resolution asking the Department of Rural Education to organize a committee that should be representative of both the farming and the educational interests of the State for the purpose of formulating a program for rural school betterment. Sufficient time has not since elapsed to permit large accomplishment as a result of this action. It is already evident, however, that there is need for a larger and more exact body of information regarding school conditions in the State than is at hand. Our Department of Rural Education should have members on its staff who are free from the restrictions of the Vocational Educational Act so that they may cooperate with the State Department of Education in making such studies as will furnish the necessary data.

The need for a body of well-prepared men and women for leadership in developing the professional phases of rural education in the State becomes daily more apparent. Such men and women are required to administer and supervise the rural schools, and to prepare teachers for service in them. While these persons should be of the highest professional attainments, it is quite as important that they should be intelligently sympathetic with life in the rural community. They should be familiar with the economic and social problems of the community. The background of a college of agriculture makes it the logical institution to prepare persons for this service. Especially is this true in our own College, in which the economic phases of the work have a comparatively large measure of development and the sociological phases are well started.

The suggested development involves no duplication of the work of the State Department of Education. It will be a means of supplementing the activities of the latter. The College of Agriculture recognizes that responsibility for the administration and supervision of the schools of the State is vested in the State Department of Education. The suggested

additions will provide a means of furnishing trained leaders such as must be available if the State Department of Education is to carry forward a progressive program in rural education. They will also make possible such a degree of cooperation in investigative work as will strengthen the teaching in the Department of Rural Education and will furnish data that are needed for the guidance of the State Department of Education in administrative action.

Changes in the staff

During the year covered by this report there have been a number of important changes in the staff. We have lost the following valued teachers, who have accepted calls to other fields: Karl J. Seulke, Professor of Animal Husbandry; Mark J. Smith, Assistant Extension Professor of Animal Husbandry; John H. Voorhees, Assistant Extension Professor of Farm Crops; Warren K. Blodgett and James L. Strahan, Assistant Extension Professors of Rural Engineering; Lex R. Hesler, Assistant Professor of Plant Pathology; Royal Gilkey, Assistant Professor in Extension Service; B. A. Chandler, Assistant Professor of Forest Utilization.

The following appointments have been made since July 1, 1919: E. L. Worthen, M.S., formerly of the Pennsylvania State College, Extension Professor of Soil Technology; Dr. J. E. Butterworth, formerly Dean of the College of Education of the University of Wyoming, Professor of Rural Education, in charge of the work in rural school administration; Miss Cora E. Binzel, formerly of the University of Wisconsin, Acting Professor of Rural Education, in charge of the professional work with prospective teachers of homemaking; Dr. E. N. Ferriss, formerly of the University of Oklahoma, Acting Assistant Professor of Rural Education, in charge of the work in secondary education; J. D. Brew, B.S., formerly of the State Experiment Station, Assistant Extension Professor of Dairy Industry; Dr. E. L. Palmer, formerly of Iowa State Teachers College, Assistant Professor of Rural Education, in charge of the Cornell Rural School Leaflet; Dr. L. H. McDaniels, Assistant Professor of Pomology; Miss B. E. Scholes, B.S., Assistant Extension Professor of Home Economics; F. G. Behrends, B.S., Assistant Extension Professor of Rural Engineering; R. M. Adams, B.S., A.B., Assistant Extension Professor of Vegetable Gardening; Dr. H. W. Dye, Assistant Professor of Plant Pathology.

On May 1, 1920, the Board of Trustees appointed Dr. Cornelius Betten, who for five years has served the College with conspicuous success as Secretary and Registrar, to the newly created position of Vice Dean of Resident Instruction, a position for which he is eminently qualified by training and experience and the confidence of his associates. On June

21 the Board appointed Dr. W. H. Chandler to the new position of Vice Director of Research. Dr. Chandler came to the institution in 1913 primarily to engage in pomological research. When Professor C. S. Wilson was appointed State Commissioner of Agriculture in 1916, Dr. Chandler was made head of the Department of Pomology. His scientific accomplishments, together with his demonstrated ability in administration, commended him to his colleagues and to the Director for the more responsible duties of the vice-directorship of research. On June 21 the Board of Trustees appointed Dr. Robert P. Sibley, formerly of Lake Forest College, as Secretary of the College of Agriculture.

The student enrollment

The number of students registered during 1919–20 shows a partial return to pre-war conditions. That the return is retarded in comparison with that of other colleges in the University doubtless reflects the agricultural situation in the State, particularly the shortage of farm labor which in many cases forces the farm boy to remain at home. It is probable that the greater financial return in other industries also has its influence. The figures for 1919–20 and for the preceding year are given.

	1919–20		1918–19	
Regular undergraduate students				
Freshmen	414		259	
Sophomores	247		241	
Juniors	253		197	
Seniors	302		174	
		1,216		871
Special students		89		43
Winter-course students				
Agriculture (General)	231		44	
Dairy Industry	55		14	
Poultry Husbandry	48		7	
Fruit Growing	22		......	
Home Economics	21		8	
Flower Growing	10		3	
Vegetable Gardening	9		7	
		396		83
Summer school students		530		493
Graduate students		229		166
		2,460		1,656

The total number of different individuals registered during the year is 2356. The fact that the numbers of students in the upper three classes are in the inverse of the normal relation is of course due to the return of students from war service.

Phases of instruction

The changes in the courses during the year are not striking. In the new Department of Rural Social Organization a course on the rural family and one on social studies in the high school have been added. The Department of Meteorology has instituted a course on the use of meteorological instruments.

The School of Home Economics has added a course on health in the home, one on diet and disease, a teachers' course on foods and nutrition, and a seminary on nutrition. In connection with the course on diet and disease, clinical work was done with patients under the care of the university medical advisers; similarly, the teachers' course gave opportunity for clinical work in the Ithaca public schools. The feeding of a healthy babe and of an older retarded child was studied in connection with the course on nutrition and dietetics.

The Department of Forestry has rearranged its curriculum, abandoning the former plan of having both formal instruction and field work in the summer term. The lecture and recitation courses of this term have been transferred to the first and second terms. The three months of field work to be done with a forestry party or in a forest industry is moved forward from the first term of the senior year to the summer following the freshmen year, and in addition a month of field work under the direction of the department staff is required in a subsequent summer.

It is gratifying to record that for the second time the fellowship in landscape architecture in the American Academy in Rome is awarded to a graduate of the Department of Landscape Art. Among fourteen competitors, two graduates of the department — Ralph E. Griswold, '16, and Fabian McK. Smith, '17 — qualified in the preliminary trials, the former being given the final award with Mr. Smith standing second. Edward G. Lawson, '13, is just completing the fellowship term of three years which he won in the only previous competition.

During the year the Trustees of the University purchased the Mead farm of forty acres and made it available for the purposes of the State College of Agriculture. The farm has been rented by the College for a number of years. Because of its location, near the barns, it is a very valuable permanent addition to the facilities of the College.

THE EXTENSION ACTIVITIES

The organization of the extension service as such was effected on July 1, 1914. The period from 1915 to 1918 was one of rapid and wide expansion. The farm bureau system was developed for the entire State and the home bureau system for half the State, the junior work was established, and specialists were employed in thirteen of the sixteen departments of

the College to carry forward the technical demonstration work in the field. This expansion was made possible by increases in funds under the Smith-Lever and the state appropriation acts, and by the war emergency funds provided by the Federal Government.

The work was conducted during 1919–20 under the same administrative arrangement as in the previous year. The transfer of the office of state leader of Home Demonstration agents from the Extension Department to the School of Home Economics, and the placing of the county agent leader in charge of administrative relationships with county organizations involving both farm and home bureaus, has effected better correlation with both the subject-matter and the field organizations.

The fiscal year ending June 30, 1920, has necessarily been one of consolidation and coordination of the efforts of these various divisions, and the general rounding out and better relating of the college service to the county organizations cooperating in the support of county agent work.

Progress and results

The Extension Service in now more complete, more comprehensive, and more effective than ever before in its history. Much progress has been made in the organization of definite projects to meet the county programs of work. A few of the specific and noteworthy developments of the year are here recorded.

Better correlation has been brought about between county agents and specialists in solving county programs. The factor that has contributed the most to this end has been group conferences between county agents and specialists. The establishment of a regular systematic news service, prepared by specialists for the farm and home bureau news and furnished through the Office of Publication, has also helped.

The Extension Service has been made more nearly adequate to the needs of the State by the addition of specialists in entomology, farm crops, vegetable gardening, rural engineering, and home economics, and by the organization of the junior extension office. Monthly conferences of all members of the Extension Service have been held, and these have resulted in much better understanding of the whole program of the College and of the relation of its parts to one another, and generally in better team work.

Considerable progress has been made in bringing the facilities of the Service to bear on the problems of marketing and distribution as well as on those of production. This result has been attained more by a redirection of present forces than by the appointment of new persons. While only a beginning has been made, the total results are already large.

The initiating and successful carrying out of three Farmers' Field Days during the last days of June marked a new and promising effort to bring

farmers of the State into more direct and intelligent contact with the College of Agriculture and with its possibilities for service.

The reorganization of the reading courses in agriculture to bring them into better relationship with the general publication and news service, and the beginning of the development of systematic correspondence courses, also marks a progressive step.

Group activities

A large part of the extension work of the departments of the College is carried on through institutes, schools, and meetings in which two or more departments are represented. These are arranged by and through two central extension offices, one in agriculture and one in home economics. All these activities, in fact practically all extension work except state-wide meetings and exhibits and the distribution of bulletins, are conducted through and in cooperation with the county farm and home bureaus. The organization and administration of these bureaus is supervised by the central farm and home bureau offices under the general direction of the county agent leader, who is responsible for working agreements with the county associations, for financial arrangements, and for the general supervision of the county agents' work.

The extent and character of the activities of the Extension Service can best be indicated in a summary of meetings, attendance, publications, and news printings. The personal contacts here recorded, numbering more than a million, probably represent actual contacts with from 150,000 to 200,000 different individuals.

SUMMARY OF GROUP ACTIVITIES

Agriculture

Type of activity	Number of persons reached	
Extension schools, 49	1,699	
Farmers' institutes, 379	29,312	
Lectures by specialists, 1,040	65,917	
Demonstration meetings, 1,143	44,106	
Conferences, 884	19,009	
Farm visits and inspections, 3,885	3,885	
Farmers' Field Days, 3	7,000 (est.)	
Better-Seed Special, 1	1,916	
Farmers' Week, 1	2,654	
Exhibits at State Fair	No record	
Exhibits at county fairs, 25	48,600	
Total		224,098

Home economics

Extension schools, 41	2,735	
Lectures by specialists, 418	26,859	
Demonstration meetings, 344	15,562	
Conferences, 86	1,707	
Exhibits at State Fair	No record	
Total		46,863

Miscellaneous

Lectures, committee meetings, and conferences by county agent leaders, 211	12,068	
Meetings and demonstrations organized or addressed by county agricultural agents, 6,587	385,913	
Total		397,981
Lectures, committee meetings, and conferences by home demonstration agent leaders, 361	18,673	
Meetings organized or addressed by county home demonstration agents, 4,466	213,185	
Total		231,858
Meetings organized or addressed by state and county junior extension leaders, 8,317		137,433
Grand total of personal contacts through Extension Service		1,038,233

Farm and home bureaus

The farm bureau movement was begun in this State about nine years ago (in 1911) and its organization was completed in 1918. It has had a rapid but sound growth, chiefly because it is based on the principle of self-help as exemplified in the county associations.

Two outstanding developments have marked the past year in relation to the individual farmer membership in the fifty-five farm bureau associations. The first of these was the almost unanimous decision by the several associations to amend their constitutions to provide for an increase in the membership fee from $1 to $2 for the year 1920. The second was the excellent response from the farmers in returning a membership of 55,766 as of June 30, 1920. While this means 10,959 less members than in the preceding year, it should be noted that, since the fee was doubled, the amount of funds contributed by the farmers was nearly doubled. The reason for the increased membership fee was that the bureaus needed more funds to carry on their programs and to support state and national federations. A more liberal financial support of their organizations by the farmers may also beget a more active interest, and more real work for their success.

Home bureau work, which was begun in 1915 but experienced its largest development during the war, has made much progress toward permanent organization in the past year. Home demonstration agents are now employed in twenty-five counties and two cities. The central office of home bureaus, located in the School of Home Economics, works under the general direction of the county agent leader in making the cooperative contacts with the executive and advisory committees in the organization and supervision of the home bureau activities. A further report of the work is given on page 48, under *Home Economics*.

In the twenty-five counties already organized, there is being effected as rapidly as possible a reorganization providing for a joint farm and home bureau association, with two departments, jointly directed by a board of directors of men and women. In these counties the organization is recognized by law as a *County Farm and Home Bureau Association* (Section 28-A, Chapter 499, Laws of New York, May 9, 1919).

The executive committees. The executive committees work more and more efficiently year by year. The reasons are obvious. As the work develops and broadens, the responsibilities of the bureaus are increased. The members of the executive committees, realizing these responsibilities, are giving more serious thought to directing the work of the county agent. They give freely of their time and their energies.

Defining relationships. For the purpose of defining clearly the relationships and points of contact between the state office and the county associations, and for purposes of record, memoranda of understanding have been drawn up by the state office and adopted by the county associations covering the following points:

1. A revised form of constitution and by-laws for county farm and home bureau associations.

2. An agreement between the county association and the county board of supervisors concerning county appropriations.

3. A revised agreement between the state county agent leader and each county association covering the maintenance and operation of the farm and home bureau for 1920.

Correlation and systematization. Considerable progress has been made since last year in correlating the methods of work in the field with projects, and in the offices with records and reports. Progress has been made also in the detailed administration of the work. A new form of double-entry financial records has been installed for both branches of the work, and provision has been made for annual inventories of the property of the bureaus. Material progress has been made in bringing the field program of the agents into line with the projects of work organized and supervised by specialists, although much yet remains to be done.

An advance in methods of holding conferences of county agents and extension specialists was furnished in the five regional conferences held in the early part of April, 1920. At these conferences, which were of three days duration, opportunity was provided for the county agents to confer individually with each extension specialist, to make definite plans for the field work during the coming season, and to make arrangements with specialists for a definite amount of assistance. As a result of these conferences a much better understanding and acquaintanceship was created.

Supervisory activities of central office staff. To assist in developing the efficiency of every farm bureau association in the State is the chief work of the staff of the central office. The activities of this force fall under at least five heads:

1. Assisting agents and executive committees in strengthening and developing their county associations.
2. Holding personal, district, and state-wide conferences of agents.
3. Rendering personal assistance to agents in the correlation of office and field work.
4. Effecting cooperative relationships between farm bureau associations and other interests.
5. Inspecting and summarizing reports and records.

Changes in personnel. An unusual number of changes in the personnel of the central office staff and among the county agents have taken place within the past fiscal year.

Professor H. E. Babcock, formerly State County Agent Leader, resigned from that office on June 1, 1920. Jay Coryell was promoted from Assistant Leader to County Agent Leader, assuming his new duties on June 1.

T. E. Milliman, who had been Assistant County Agent Leader during the greater part of the year, resigned on October 1, 1919, to assume the managership of the organization department of the Dairymen's League. L. A. Toan, Assistant State Leader, resigned on June 1, 1920, to take up work in connection with a seed firm in western New York. To fill these respective vacancies, L. R. Simons, formerly agriculturist in the office of the States Relations Service at Washington, D. C., and C. A. Taylor, who for the past five years has been county agent in Herkimer County, were appointed. Mr. Simons and Mr. Taylor assumed their new duties on June 1, 1920.

Between July 1, 1919, and June 30, 1920, twenty-three county agents, or nearly 42 per cent of the entire number, resigned or were changed from one county to another. Many of the county agents have left the work primarily because of better financial opportunities elsewhere. This has been the largest overturn among county agents in New York State since the bureaus were organized.

Schools, institutes, and community meetings

Extension schools in agriculture. During the winter of 1919–20 there were 49 farm demonstration schools held, with a total enrollment of 1699. This is nearly double the number of schools held during the winter of 1918–19, and more than double the total enrollment. In spite of the severe winter there were eighteen schools with a roll of 40 or more, as against three for the preceding year.

The three-days schools begun last year proved very popular, 31 out of the 49 schools held this year being of that type. Most of these were for special work, such as with gas engines and milking machines, and for potato growing. There were three potato-growing schools held, with an average enrollment of 38 persons. The five milking-machine schools, with an average enrollment of 41.6, also proved highly successful. Probably the most popular of the new three-days special schools were the gas-engine schools, of which ten were held with an average enrollment of 29.9. Although most of the three-days farm-mechanics and milking-machine schools required an additional instructor on the third day, the average number of instructors (2.4) is lower than ever before.

Special effort was made this year to introduce demonstration material into the courses, and the students were urged to furnish material for local exhibits for study and judging.

A summarized statement relating to the extension schools follows:

Number of schools held	49	
Counties reached	28	
Total enrollment (48 schools)	1,699	
Average enrollment (48 schools)	35.40	
Largest enrollment	72	(Rochester)
Smallest enrollment	6	(Troupsburg)
Highest percentage of attendance	90.25	(Interlaken)
Average attendance at each session (49 schools)	23.48	
Average number of instructors to each school	2.4	
Length of school season (weeks)	16	

Instruction was given as follows:

	Number of days	Number of schools
Agricultural chemistry	2	1
Animal husbandry	56	16
Dairy	15	5
Entomology	4	2
Farm crops	46	14
Farm management	7	3
Plant pathology	15	6
Pomology	19½	7
Poultry	8	3

	Number of days	Number of schools
Rural engineering	147	26
Soils	33	8
Vegetable gardening	2	1
Miscellaneous (Outside assistance)	9½	3

Farmers' institutes. This year 21 more farmers' institutes were held than in the season of 1918–19. The number of institutes scheduled was 395, but 16 of these were canceled because of illness in the communities or because of bad roads. The attendance at the institutes this year, however, showed a considerable decrease. The average attendance for the whole season was 38, as compared with 56 for last year.

Homemakers' conferences were held at all but 19 of the institutes. The decrease in attendance at these conferences was not so great as in the meetings for men. This year the average attendance at homemakers' conferences was 22, while last year it was 26.

Seven two-days institutes were held this year. Twelve persons were employed regularly, and thirty-nine were employed at irregular intervals or for short periods. The following table shows comparative figures for 1919 and 1920:

	1918–19	1919–20
Number of meetings	358	379
Number of sessions	745	772
Number of homemakers' conferences	321	360
Attendance		
Total	41,642	29,312
Men	33,160	21,429
Women	8,482	7,883
Average attendance per session	56	38
Women	26	22

Community meetings. The greater part of the extension activities in the past year comprised single-session meetings. During the winter such meetings are more or less general in character, though most of them are called for the purpose of discussing some specific problem. During the summer the specialists give their chief energies to training, directing, and supervising local leaders in the conduct of field trials and making local demonstrations of the value of general recommendations. This work is described in the reports of the several subject-matter departments.

The totals of meetings other than schools and farmers' institutes for the eleven months ending May 31, 1920, are: 3746 days in the field; 875 demonstrations, attended by 45,135 persons; 1024 lectures to 63,759 persons; 788 conferences and conventions, with 17,219 present; 3147

inspections; and 218 days with exhibits at fairs and similar gatherings.

There were in addition a number of group projects, as Farmers' Week, summer field days, demonstration trains, exhibits at fairs, district conferences with county agents, and other special conferences, which are reported elsewhere.

Better-Seed Special. In the spring of 1920, a "Better-Seed Special" demonstration train was operated over the lines of the Lehigh Valley, the Erie, the New York Central, the New York, Ontario, & Western, and the Delaware and Hudson Railroad Company, through 21 counties in eastern New York. This was the continuation of a similar train operated through western New York the preceding year.

The cars were in operation 22 days, making 46 stops in the 21 counties, with a total attendance of 1916 persons, or an average of 41.7 to each stop. Unusually difficult travel on most country roads during March resulted in low attendance.

Farmers' Week. The thirteenth annual Farmers' Week was held at the College February 9 to 13. The total registration was 2654, with a probable attendance much greater than that. It was apparent, however, that there was a material falling-off in the attendance as compared with previous years. This is believed to be due to difficulties attendant upon illness and interruptions to transportation. The program did not differ materially in character from that of previous years and the interest was good throughout. A country newspaper day was a new feature. In addition to the regular staff of the College of Agriculture, seventy-four outside speakers took part in the program, which may be summarized as follows:

Lectures given	243
Demonstrations and round tables	105
Conventions and conferences	9
Practice periods	32
Exhibits	20
Entertainments and banquets, including motion pictures	11
Contests, including students' judging and speaking	10
Registration for week	2,654

Field Days. The Farmers' Field Days, held on June 30 and July 1 and 2, established a new event for this College, although other similar institutions have for several years held large summer farmers' meetings at the experiment stations. The primary object is to provide opportunity for relatively large groups of interested persons to inspect, under the guidance of members of the college staff, the farm operations and experiments being conducted at the college station at a season of the year when growing crops can be viewed to the best advantage, affording in many cases ocular demon-

stration of the relative value of certain practices, and particularly the results of long-time experiments.

For the most part, farmers came for one day only, and nearly all came by automobile. The middle day of the three brought by long odds the largest attendance. It did not seem practicable to register the visitors. It is probable that there were 5000 present on the middle day alone, and about 1000 on the first and on the last day. The project was considered entirely successful, and it will be repeated, with certain minor modifications suggested by this initial experience.

Junior extension

Much progress has been made during the year in the junior project work carried on by the Department of Rural Education in cooperation with the State Department of Education. In addition to these organized efforts, some work has been done in every county in the State through county agents, superintendents of schools, teachers, and interested individuals, particularly in effecting organization on a permanent and county basis. Eighteen counties have employed leaders during all or a part of the time.

Twenty-one counties had definite organizations for directing the work during 1919. These organizations, known as county boards of junior extension, are composed equally of representatives of county farm and home bureaus, and representatives of the schools including school superintendents. These boards act in an advisory capacity, but they are usually responsible for the raising of local funds and for the local direction of the work.

These county leaders have been helped by two college specialists in homemaking, one in gardens and crops, and one in poultry. The College has furnished publications and record books also.

The scope of the work is indicated by the following twelve approved projects:

Gardening	Calf raising
Potato growing	Pig raising
Corn growing	Sheep raising
Bean growing	Cow testing and record keeping
Poultry raising	Food (including canning)
Rabbit raising	Clothing

The work in each of these projects is divided into three classes or grades, according to the age of the worker, as follows: Class A, children up to 11 years old; Class B, children from 12 to 15 years old; Class C, girls and boys from 16 to 19 years old.

There were 263 leaders, some of them paid and some voluntary. These leaders reported a total enrollment in all projects of 20,686 workers, of whom 14,817, or 17.6 per cent, had reported their projects completed on December 1, 1919. Local supervision has been provided by the school boards of education.

County and local fairs have shown an increasing interest in the work, and many school and community fairs or achievement days have been held, at which project workers have received achievement pins furnished by the State Bankers Association, and certificates furnished by the State Department of Education. The State Fair Commission, through generous appropriations, made possible the exhibition of each of the projects in a separate booth and the paying of the expenses of eight of the championship demonstration teams to the fair. These teams were later sent with exhibits to the Eastern States Exposition at Springfield, Massachusetts.

Publications

A new development in the Office of Publication during the year was the beginning of extension work with country newspapers, recognizing the country newspaper as an important agency in rural development. An investigation as to present tendencies in the field of the country weekly revealed the needs which the College has endeavored to meet by furnishing a regular news service in agriculture and home economics to the rural press. A country-newspaper conference was held at the College during Farmers' Week, and ribbons were awarded respectively to those papers that presented the best front page make-up, and to those that served their communities best.

The major part of the work of the Office of Publication has to do with the extension of agricultural information through print. This is done by means of the regular publications listed as a part of this report, by the Extension Service News, by the Service Sheet to country newspapers, by the regular news service to the farm bureau papers of the State, by counsel and conference with the farm and home bureau managers for the improvement of the papers issued by each county farm bureau, and by news service to the daily and the weekly press.

The news service to the press has been increasingly used, and the circulation of news items during the fiscal year was more than one hundred million separate printings, as compared with 67,236,205 during the preceding year. This record is based on clippings actually seen at the College.

Among the resolutions passed by the Association of Agricultural College Editors at its meeting in Amherst, Massachusetts, on June 30, 1920, was the following: "*Resolved*, that this Association indorses the pioneer efforts in 'extension work for country newspapers' made by the New York

State College of Agriculture at Cornell University, and recommends that it be brought to the attention of the States Relations Service, United States Department of Agriculture, and to the state directors of extension, with a view to including 'extension work for country newspapers' in the extension programs of other States." This association consists of representatives from forty-one colleges.

Ninety-three publications of the College and Experiment Station, with a total circulation of more than a million and a half copies, have been printed and distributed to the people of the State and to teachers and investigators in other States. A list of these publications is given on pages 74 to 77.

On July 5, 1919, the rented storage warehouse in which reserve supplies of publications were kept was burned to the ground, together with its contents. Provision has since been made for a more suitable storage building.

Reading course for the farm. During the past year a committee has made a study of the reading-course situation and has submitted recommendations which have been adopted, with a view to putting the systematic study of reading-course lessons on a more definite footing. These recommendations provide for the elimination of duplications in mailing lists, for the reduction of the distribution of reading-course lessons to those actually returning the lessons, for the more careful supervision of the readers, and for the establishment of Cornell farm study courses. It is planned to use the bulletins of the United States Department of Agriculture and the Geneva Experiment Station in the farm study courses, and to expand the advanced reading courses.

In the latter part of 1919, the supervisor of the reading course, Assistant Professor Royal Gilkey, who during a leave of absence had been teaching agriculture at Greene, New York, decided to continue teaching, and resigned from his position at the College. During Professor Gilkey's absence Professor D. J. Crosby carried the work of his office. Before the end of the fiscal year arrangements had been made to transfer the work of the Farm Study Courses to the Office of Publication.

Extension in rural education. The appointment of Assistant Professor E. L. Palmer, in the Department of Rural Education, as editor of the Cornell Rural School Leaflet, has made it possible to again issue that publication regularly. The calls that came from district superintendents and teachers during the year when publication was suspended is ample evidence that the Leaflet is filling a real need in the rural schools of the State.

Exhibits

Each year the College exhibits some phases of its work at the State Fair, at the county fairs so far as its funds and the time of its staff permit,

and at certain other expositions as occasion demands. This work is a severe tax on college resources, since no special provision, either of men or of money, is made by the State for the work. Provision for these exhibits constitutes one of the needs of the institution.

The State Fair. In 1919 the College featured as its main exhibit at the State Fair the production, care, and handling of clean milk and the use of milk as a food. The central part of the exhibit was a model layout for a dairy farmstead. The model showed not only the arrangement of the entire farmstead, including plans for planting the home grounds, the gardens, the orchard, and the poultry and pig yards, but also, by plans and in model form, two houses, one for the owner and one for the tenant, and the dairy barn, the ice house, and other buildings sufficient for a dairy farm of 150 acres. These plans were complete in detail, showing floor plans and specifications for building and the approximate cost of construction. By enlarged photographs and charts, different types of dairy barns were shown, giving the visitors at the fair very definite information on the construction of farm buildings. Adjacent to the farmstead was an enlarged model of a section of the dairy barn, showing the method of construction and the lighting and ventilation systems.

Other parts of the college extension program which were illustrated by exhibits at the State Fair included the care and handling of milk, with emphasis on proper cooling; the value of milk as a food, especially for growing children, demonstrated by milk drinks sold over a "milk bar"; clothing materials and the making over of garments; the making of butter, cheese, and ice cream; the value of artificial lighting for egg production; soils of the State and their proper treatment; floriculture; publications; and the junior project work with girls and boys. While the setting up of such exhibits and their proper use during the fair is difficult and expensive, an excellent opportunity is afforded for graphic presentation to thousands of persons who might not otherwise know of the work of the Extension Service of the College.

County fairs. During the year 1919 the College cooperated with the county farm bureaus in making exhibits at county fairs. Five departments of the College assembled exhibits in response to requests, these exhibits being used as parts of the county farm bureau exhibits. The subjects covered were drainage, injurious insects and plant diseases, legumes, and sheep and wool.

Exhibits were scheduled for 27 counties, but delayed transportation necessitated six cancellations and exhibits were actually shown in 21 counties. Three of these counties had two exhibits, and one county had the same exhibit twice. Approximately 48,600 persons saw the exhibits, and 1351 consulted the specialists in entomology, poultry, and rural engineering, who spent 68 days at the county fairs.

Other exhibits. Exhibits were made also by departments of the College at the Rochester Industrial Exposition, at the annual meeting of the State Fruit Growers' Association, at the Madison Square Garden Poultry Show, at the New York Milk and Child Health Exposition, and at other meetings. At the last-named exposition there was a paid attendance of 23,928 persons. The exhibit of the College at the annual conference of the American Association of Agricultural College Editors was the only one to win awards in all three classes represented, and it took first place as best exhibit.

Animal Husbandry

Extension work in animal husbandry is one of the largest extension enterprises of the College, and, because of the importance of livestock, particularly dairy cattle, in the State, one of the most in demand. Five members of the department gave their entire time to it during the past year, and several others gave considerable time.

The lines of work emphasized during the year included better-stock and bull associations in 26 counties, dairy and pig-feeding projects in 18 counties, sheep and wool-marketing associations in 36 counties, cow-testing associations in 33 counties, 30 or more barn demonstrations, 30 active breeding clubs, and fairs and exhibits. The work was well distributed throughout the State.

At the beginning of the second semester Professor M. J. Smith resigned as sheep specialist. As a result the work with sheep has been handicapped. Through the cooperation of the Bureau of Animal Industry of the United States Department of Agriculture, Dr. B. J. Cady gave us much assistance during the remainder of the year, particularly in connection with the health of farm animals.

The supervision of advanced registry records of dairy cows has been continued. This phase of the extension work demanded the time of from twenty to one hundred men at different periods during the season. Assistance was given to about five hundred breeders in the State. This is a main feature of the extension work. In addition to its educational value, it promotes the financial advantage of the breeder through stimulating interest in purebred stock.

Botany

No extension specialists in botany are employed, but considerable extension work is done by the regular staff. Ten thousand cultures containing organisms for inoculating soil in preparation for legume crops have been prepared and distributed to farmers, chiefly through county agents, during the year, and assistance has been given to several hundred farmers in weed identification and eradication.

Dairy Industry

On September 1, 1919, G. C. Dutton, extension instructor in the Department of Dairy Industry, resigned to accept a position at a larger salary elsewhere, and on November 1 Dr. James D. Brew was appointed in his place as Assistant Extension Professor. Dr. Brew has specialized on problems relating to market milk supply. Mr. Ayres has continued his field work among the dairy manufacturing plants of the State, giving special attention to helping former students in their problems. Four-tenths of his time goes to extension; the remainder is spent in teaching at Ithaca.

Extension in dairy industry has dealt with the production of high-grade milk, the marketing of dairy products, the Babcock test for butterfat grading of milk, the value of milk of different compositions, and problems in creameries.

Entomology

Three main lines of extension in the Department of Entomology are: first, demonstrations in the control of injurious insects affecting fruit, vegetables, and domestic animals, conducted by Professor C. R. Crosby and M. D. Leonard; second, demonstrations in bee keeping, conducted by George H. Rea; and third, work with birds and mammals, conducted by Dr. A. A. Allen and C. R. Leister.

In some counties the demonstrations on injurious insects affecting fruit and vegetables is done through the field assistants whose work is described elsewhere under "Plant Pathology," and is under the immediate supervision of Mr. Leonard. In other counties, entomological demonstrations are confined principally to showing how to control insects when serious outbreaks occur, as, for example, of grasshoppers, cutworms, or army worms. The control of the ox warble fly is being organized in certain dairy counties.

In August, fields in the wheat-producing regions of the State were examined to determine Hessian fly infestation. The facts as to the degree of infestation thus learned afforded the basis for definite recommendations for fall sowing. The benefits to growers who followed college recommendations more than paid the entire cost of the work.

Extension in bee keeping has acquired much popularity during the past two years. It has been aimed chiefly at the control of American and European foul brood by educational methods. These diseases, together with improper wintering, have caused the loss of not less than half of the bees in this State. Hence extension efforts have been aimed at control through better wintering methods, cleaning up old infections, and preventing new ones. Bee breeding through purebred stock is another method used for improvement. The organization of 21 new county beekeepers' associations, the holding of county meetings and field days at which the

methods mentioned above have been discussed and demonstrated, and the arranging for lectures and schools, have been the chief means used by Mr. Rea.

In the work with birds, the effort has been principally in the direction of conservation and encouragement, although some attention has necessarily been given to questions of control of certain partly injurious kinds. In the case of mammals, the work has consisted almost entirely in giving assistance in the prevention of injury to fruit, trees, and crops, by meadow mice, moles, rabbits, and woodchucks. The correspondence on these subjects is particularly heavy.

Deserving of mention as part of the extension work of the department are the following:

The work of Dr. James G. Needham, in cooperation with Dr. E. L. Palmer, in the preparation of a Rural School Leaflet in the interest of keeping the waters clean, and that in cooperation with the Conservation Commission in the direction of a biological examination of Lake George; the work of Dr. G. C. Embody in cooperation with the University of Washington in inaugurating in that institution a study of fish-breeding problems; and the work of Dr. P. W. Claassen and Hazel Branch in cooperation with the Milk Conference Board in developing biological methods for disposal of milk wastes.

Farm Crops

Demonstrations of methods of crop growing have been carried on in all parts of the State by the Department of Farm Crops in cooperation with the local farm bureaus. The chief lines of activity consisted of the growing of silage corn and of husking corn, pasture improvement, vetch culture, the establishing of alfalfa, and potato culture, while minor attention has been given to sweet clover, wheat, oats, and other crops. The demonstrations were laid out with the object of teaching methods of crop growing or of showing that certain strains or types of seed are the best.

Great interest in pasture improvement has been manifested. Demonstrations have shown farmers that pastures can be improved, and that such improvement is valuable and economical. Applications of pasture grass mixtures, acid phosphate, and lime have been used with good results. Some culture, such as harrowing or plowing, has been shown to be advantageous. So good were the results of these demonstrations, and so keen was the interest of farmers, that pasture improvement has been undertaken by farmers in New York on a greater scale this season than ever before. In Otsego County more than one hundred farmers are this year carrying on pasture improvement under the direction of the county agent.

Demonstrations with alfalfa have shown that the use of seed of the variegated alfalfa grown in the Northwestern States promises success. Not only does such alfalfa usually yield more, but it is more permanent. Through the activities of the extension specialists in farm crops and the various farm bureaus, more than 100,000 pounds of hardy northern-grown alfalfa seed of high quality was brought into New York during the spring months of 1920.

For several years the Department of Farm Crops, in cooperation with the State Potato Growers' Association, has been encouraging the production of certified and inspected seed potatoes. The attention of farmers has been called to these potatoes. Usually, however, the supply of such seed has been much larger than the demand. Comparisons have recently been made, through demonstrations, of the yield from the best strains of such certified seed and that from common seed in the hands of farmers. In Orleans and Seneca Counties in 1919, the average yield of the best strains of certified seed exceeded that of common seed by about 100 per cent. The result was that in the spring of 1920 the demand for certified seed was much larger than the supply, and for the first time the whole supply of certified seed was used for planting. Efforts are now being made to increase the best stocks so that there will be enough to meet all planting needs. It is believed that by this work, yields may be greatly increased without added efforts in cultivation.

Similar demonstrations with other crops give results equally striking. Efforts are being made to increase the best strains and to have them adopted by farmers.

To further this work the fields of farmers growing good strains of the various crops are inspected by the extension specialists of the department. Crops which are well grown, of a pure variety, and free from noxious weeds and disease, are listed. During the past year about one hundred farmers had fields of wheat, rye, oats, corn, or beans which passed such inspection. Through printed information from the College and through the county agents, farmers were informed of the existence of these supplies of good seed.

Assistance in judging seed exhibits at county and community fairs has been given by the department. This affords an opportunity to condemn poor seed and unsuitable varieties, and to commend those which are desirable. A crop contest has been conducted in connection with the Cayuga County Farm Bureau.

The greater part of the months of November, December, January, February, and March were devoted to teaching groups of farmers at three- or five-days extension schools, at community meetings, and at farmers' institutes. In such teaching, especially at the schools, some of the basic

principles controlling crop production were given, in addition to reviews of results of near-by field demonstrations.

During the spring of 1920 the department was busy in making arrangements for its demonstration program for the spring and summer. More than fifteen hundred demonstrations were called for. Material was gathered, plans were formed, and the following demonstrations were made: oats 300, potatoes 125, pasture improvement 175, silage corn 90, miscellaneous 50.

During the past year about fifteen hundred letters of inquiry, on a large list of topics, have been answered. Most of the letters came from farmers who wanted information about methods of crop growing, about the adaptation of certain new crops, about seed supplies and varieties, and about destroying weeds. Many inquirers sent samples of economic and weed plants for identification. Not a few sent samples of seed for examination as to variety, purity, and germination.

During the year two men have given all their time to extension activities in the department, and for seven months of the year a third man devoted about two-thirds of his time to this work.

Farm Management

Although the services of the extension staff of the Department of Farm Management have been in great demand and a large proportion of its energy has necessarily gone into extension activities, results are difficult to measure because of the nature of the work and because results in improved farm management cannot be immediately apparent. The activities have included keeping cost accounts; surveys made by letter and by personal farm visits, the returning of summarized surveys to farmers, and publication of the results of the surveys; presentation of farm management facts at farm meetings, schools, demonstrations, Farmers' Week, and elsewhere; and many personal conferences with groups and individuals. In all nearly 9000 individuals have been reached.

Some of the outstanding achievements include: the return of 159 records for 1919, and the obtaining of the 1920 records on 154 farms in Niagara County,— the sixth successive year for these farms; the tabulation of 724 Livingston County records; the opening, supervision, and closing of complete sets of cost accounts on 41 farms; the distribution, chiefly through county agents, of 3085 inventory and 4180 cash books to farmers at cost; and the tabulation of several labor surveys for dairymen. A thorough study of the costs of growing canning crops, which may serve as a basis for the more intelligent determination of the value of these crops as between growers and canners, has been undertaken;

more than six hundred records of the cost and operation of farm tractors have been obtained; and much time has been given to the preparation and dissemination of information on prices of farm products, especially dairy products.

A survey by questionnaire, made in cooperation with the United States Bureau of Crop Estimates, of the farm population in New York State as compared with that of last year, the supply of farm labor, and the vacant houses on farms, has attracted wide attention. It was shown that the number of persons on farms in 1920 was 3 per cent less than in 1919, and that there were about 24,000 vacant habitable houses on New York State farms.

Marketing and cooperation. The main marketing problems in this State may be grouped under four heads: first, production of a better article, properly graded, standardized, and packed; second, improved storage of every description; third, improved transportation not only by steam railway but also by rural motor express; and fourth, improved financing and short-term credit, involving the use of warehouse receipts and of trade acceptances.

Most of the work done by the College looking toward the production of a standardized and improved article is being done in other departments than Farm Management. Much of the effort of many of the subject-matter departments looks toward the improvement of the quality of farm products and their better grading and packing. While this is probably necessary and desirable, there is abundant opportunity for better correlation and general direction along the lines of marketing experience and sound business principles. Results in improvement of products from the marketing standpoint are discussed under subsequent headings. Especially noteworthy are the results in marketing of fruit, vegetables, grain, milk, and eggs. Very little has been accomplished by the College as yet in the improvement of storage facilities.

A beginning has been made with transportation problems by the gathering of data for future use. The extension specialist in this field was a member of the State Highway Committee, and through this association he was able to assist in the development of the rural motor express.

Work in promoting improved farm finance and short-term credits was confined to the preparation and sending out of information through the press. Assistance was given to one or more cooperatives in the auditing of their accounts.

Much time and effort was spent in gathering data and preparing information, and by far the largest number of persons reached by any means were reached by articles sent out through the Office of Publication. A little more than eleven hundred persons were reached through field meet-

ings. Marketing programs were prepared and given in Farmers' Week and on the Field Days. The Merchants' Institute, or conference of country storekeepers, held on the latter occasion was considered the outstanding piece of work in this department during the year. Some assistance was given to farmers' organizations in developing their big marketing programs — to the Dairymen's League with milk, to the fruit-growers' cooperative packing house with fruit, to the canning-crops growers' association with the crops grown by its members, to the sheep association with wool marketing, and to the Grange League Federation Exchange, Inc. The marketing of hay received attention but led to no definite action.

Forestry

Extension work in forestry, under the immediate direction of Assistant Professor Collingwood, proceeded during the year in accordance with the program previously adopted. Special emphasis was placed on attempts to organize the cooperative marketing of forest products by community groups; on the collection of information about the maple sugar industry; on encouraging the establishment of forest plantations; and on efforts, particularly by means of demonstration areas, to foster proper methods of handling farm woodlots and other woodlands. During the year 13 lectures were given, with a total attendance of 628; five circular letters were sent out to 313 persons, and, in general extension correspondence, 912 other letters; and 22 articles of varying length were prepared for farm bureau and other newspapers.

Home Economics

The extension activities of the School of Home Economics for the year 1919–20, conducted by ten full-time and two part-time specialists, has aimed to promote three main projects — nutrition and foods; clothing, and hygiene and sanitation. In addition some incidental work has been done by other members of the staff on household management, housing and furnishing, recreation in the home, and community enterprises. These seven points really constitute the extension program of the School, and therefore the program is only about half developed. The promotion of the latter four lines awaits the appointment of extension specialists in those fields.

The work has been carried forward by lectures, demonstrations, schools, demonstration cars, study clubs, bulletins, reading courses, and the press. With the exception of the publications, the greater part of these activities have been conducted in cooperation with the farm and home bureaus, especially in the twenty-five counties and two cities having home bureaus.

The demonstrations, the schools, and, to a less degree, the lectures, were almost all conducted in cooperation with home bureaus.

In nutrition and foods 124 lectures were given, with an attendance of 6453 persons, and 20 child-feeding projects, 3 clinic demonstrations, and 16 five-days schools, were conducted. This work was done in 23 counties. The nutrition schools are meeting a real need in the community, and are far more satisfactory than the one-day meetings. One clinic demonstration has been continued as a definite piece of work.

In the extension teaching in clothing, 21 five-days and 3 three-days schools have been held. In addition to this instruction 108 demonstrations and lectures have been given, with 1068 persons in attendance. The clothing work was done in 33 counties.

In hygiene and sanitation, the work in which was begun after January 1, lectures have been given before a number of granges, women's clubs, and church organizations. As a result it has been recommended that health surveys be made in cooperation with home bureaus, boards of health, and other bodies, and that more intensive health work, based on the results of these surveys, be undertaken. An eight-page health bulletin has been completed and short articles on household sanitation have been prepared for the use of the daily papers in the State. Lists of reference books and pamphlets have also been prepared for the general use of county agents, and special bibliographies have been supplied on request. The aim of the work, both in lectures and in publications, has been to arouse interest in personal and community health and to create a desire for reliable information.

The "Victory Special," operated for 63 days, reached 12,358 persons in 22 counties.

Home bureau activities. In the counties and cities in which there are home bureaus, the communities organized for home bureau work determine, in conference with the home bureau manager and representatives from the State College, a project or a program applicable to the community conditions. The county-wide program adopted by the executive committee is made up from these individual community programs.

The following projects have been adopted and worked upon in the different communities throughout the State in the past year: clothing, junior work, labor-saving methods or devices, health, community activities. Communities have promoted community kitchens, sewing rooms, cooperative buying, day nurseries and children's play-grounds, home bureau tours, rest rooms, women's exchanges, recreation and recreational centers, community libraries, and community houses. For the working out of these programs 4466 meetings and demonstrations have been held, with a total attendance of 213,185.

The central office of home bureaus has been organized to cooperate with the executive committees in the development of this work. The State leaders have attended 361 meetings with a total attendance of 18,673.

Junior extension clubs. The most important activity of junior projects in homemaking has been the training of local leaders of clubs. Illustrated talks at teachers' conferences, and before small groups of interested persons such as school officials and home bureau members, have been given, and meetings with girls' clubs have helped them in formulating their year's program.

The plan of organizing girls into groups and of having each group directed by a local adult leader has proved good, as shown by the large number of projects completed and the excellent grade of products turned out, by the letters and special reports that have come to the specialists, by the demonstrations given by girls at school and county fairs and at the State Fair, and finally by the extension of the work from a small group to larger and larger groups by the local leaders and by the workers who come under the instruction of the specialists. This junior work has reached directly 3279 persons in 148 meetings, and, in addition, has resulted in the training of 30 groups of leaders and the giving of 76 demonstrations in foods, canning, and clothing.

Reading Course for the Home. During the year, 5554 new names have been added to the mailing list for reading-course lessons, which now contains 61,646 names. In addition, these publications are sent to the study club list of 2926 names and to a list of institutions and professional readers numbering about 2500.

Since July 1, 1919, 9031 individual requests for publications have been filled, 2499 of which came from outside the State. These were in addition to bulletins in quantity sent to home demonstration agents and others.

Cornell study clubs. There are now 107 Cornell study clubs, located in 31 counties and having a membership of 2926 women. Of this number, 25 clubs, with a membership of 808, were not organized originally for the study of home economics, but they have asked to have the material prepared for the Cornell study clubs sent to them. Programs have been prepared and distributed on the following subjects and in the following numbers: thrift, 20; health, 20; civics, 22; foods and nutrition, 6. The correspondence includes 1001 letters and 11 circular letters written to clubs. Thirty clubs have been visited by the study club leader.

Preparation of news. In October, 1919, the preparation of news matter on home economics, to be issued through the Office of Publications of the College, was made the work of one member of the extension staff. As this has developed, it has included the contribution of articles to the state press, to the Extension Service News, to the Farm and Home Bureau

News in various counties, and to farm papers. Contributions are also made regularly to the National Grange Monthly. Since January, 1919, a monthly collection of news material has been sent to home bureau agents and others, to keep them in touch with current information.

A quarterly leaflet, *The Home Economics Reminder*, has been mailed to former students and to home economics workers associated with the College.

During the year 96 articles, containing a total of 383 pages, have been sent out, and 170 letters have been written. The extension instructor in charge of this work has spent 41 days in the field, and has given 11 lectures with a total attendance of 756. In addition 14 conferences have been attended, with a total attendance of 124 persons.

Miscellaneous activities. Miscellaneous activities of the School during the past year include the operation of a community canning kitchen in Ithaca; milk demonstrations and exhibits at the county fairs and at the State Fair, and participation in the New York Milk Show. In all, 44,359 persons were reached by extension activities in this field — 22,431 through lectures, 19,725 by demonstrations, and the remainder by conferences.

Landscape Art

The extension activities of the Department of Landscape Art are becoming important in countryside development and improvement. The purpose is primarily educational. The home, the school, and the community should be livable as well as workable, and they cannot be truly satisfying unless they are attractive as well as efficient.

Data for this extension work are gathered by means of surveys and studies. The actual needs are discovered, and a sound policy on which to base recommendations is established. During the past year such surveys have dealt with farm homes and rural schools.

Information is given by means of correspondence, lectures, demonstrations, printed matter, and exhibits. Exhibits this year during Farmers' Week at the University, and at the State Fair at Syracuse, conclusively proved their worth. The increase in volume of correspondence over last year was more than 100 per cent. Nine articles have been mimeographed this year, with a distribution of approximately 4300 copies. Calls for assistance from individuals, communities, and farm bureau workers have increased rapidly.

Meteorology

In the past, little has been done in the field of extension by the Department of Meteorology. This year, in addition to supplying lecturers for various meetings in the State, the department is cooperating with the

Tompkins County farm bureau agent in furnishing local weather forecasts to interested farmers of the county.

Plant Breeding

The extension work of the Department of Plant Breeding has been conducted principally by one member of the staff, who at the same time has handled many of the experimental tests which are being made away from the College. Demonstration plantings have been made, and community demonstration meetings held in connection with them, as follows: oats, 17 plantings in eight counties; wheat, three counties; barley, two counties; rye, three counties; corn, six counties; timothy, one county.

Considerable effort has been devoted to other activities, such as inspection of seed fields, conferences with county agents, judging at fairs, attendance at community meetings, and participation in the work of the seed cars.

Plant Pathology

The demands for extension in plant-disease control have increased markedly during the past year. The most urgent problems in the State appear to be in connection with the diseases of seed potatoes, seed corn, vegetable crops, and fruit.

Seed treatment for the control of certain tuber-borne diseases of potatoes was conducted on an extensive scale during the spring in most of the potato-growing sections, under the supervision of special field assistants and graduate students in the Department of Plant Pathology. The results of demonstrations on this project show that substantial progress has been made in generalizing the practice among potato growers in this State.

A preliminary survey of the root rot of seed corn, both on Long Island and upstate, shows a serious situation. Much of the seed used in the State appears to be badly infected, as shown by examination of the seed and confirmed by field conditions. An agreement with the Suffolk County cooperative association provides for a survey, and a program of control.

The demand for special field service in the control of diseases and pests of fruit and vegetable crops is being met by placing special field assistants in the counties which request such service. The Departments of Plant Pathology and Entomology, cooperating in this project, have placed eight such assistants in as many counties this spring, working through and with the farm bureaus, the College providing $50 a month for six months and the special supervision of trained extension specialists, and each farm bureau furnishing $100 salary a month for six months — a total of $150 salary a month for each assistant. The farm bureaus also provide

and maintain cars for the use of the field men. In three other counties a similar arrangement, using the services of the farm bureau assistant for the growing season, is in operation, the farm bureaus providing all the salary. Dr. H. E. Thomas has joined the college staff as special field supervisor of these men on fruit diseases, while Dr. Charles Chupp and Dr. H. W. Dye have supervised the work on field crops and vegetables. A steady growth in the demand for this type of extension service is foreseen, and adequate provision for its needs should be anticipated.

Other extension activities of the department may be briefly summarized as follows: extension schools attended, 34, with a total attendance of 944 persons; farm bureau community meetings attended, 33, at which 934 persons were reached, largely in connection with potato diseases; letters written in reply to special inquiries during the year, 2368; special leaflets giving information on diseases and their control, sent out on request only, 105,174 copies.

Pomology

Three principal lines of work occupied most of the time of the extension specialists in the Department of Pomology—central packing houses, pruning demonstrations, and bridge-grafting demonstrations. Orchard renovation, pollination, cover crops, fertilizers, and judging at fairs, also received some attention. The demands for work in this field are growing rapidly.

The movement to organize central packing houses has been encouraged by giving information as to what has been done by other packing houses in the State; and a general plan for organization, buildings, equipment, and operation has been formulated through twenty conferences held with packing-house groups and prospective organizations.

Seventy-eight pruning demonstrations have been given during the year.

Following a winter of severe mice injury to young trees, there was an unusual call for bridge-grafting demonstrations, and twenty-two of these were given.

Correspondence has been heavy. In addition, 91 lectures, 55 inspections, 16 conferences, and 10 days at exhibits, have given instruction in general fruit culture. This was further supplemented by the farmers' institute lectures in pomology.

Poultry Husbandry

The extension program in poultry husbandry includes culling to eliminate undesirable birds; certification of the best birds for breeding purposes; improvement of flocks by the distribution of Cornell pedigree

cockerels and Cornell pedigree chicks; and the Cornell advanced registry for officially recording superior birds.

Practical results from the 451 lectures and demonstrations held in 1919–20, with 16,463 persons in attendance, the 96 days spent with exhibits, and the 683 farm visits, include not only an increased and more intelligent interest in poultry husbandry, but also, more specifically, the pledging of 305,975 fowls for selection, and the certification of 13,628 others on 164 farms in 40 counties with an estimated saving of $138,263.30 to the owners.

Rural Engineering

Special emphasis has been placed by the Department of Rural Engineering during the past year on its extension demonstration schools, in which particular attention has been given to the gasoline engine. Engine efficiency is proportional to the skill and knowledge of the operator, other things being equal.

Tractor schools, successfully conducted for the past two years by the New York State Food Commission, were taken over this year by this department. Four have been held, one each at Rochester, Buffalo, Gouverneur, and North Rose. The average attendance was 50.

The following extension schools have been conducted: Twelve three-days gas-engine schools, with an average attendance of 28.2; five three-days milking-machine schools in cooperation with the Department of Dairy Industry, average attendance 23; four farm-mechanics schools in cooperation with other departments, average attendance 29; two special schools, one at Alfred with an average attendance of 25, and one at Columbia University with an average attendance of 20. Aside from these schools, members of the department have conducted 23 single-session meetings on special subjects, such as the tractor, lighting plants, the effect of the gas engine on eastern agriculture. The total attendance at these sessions was 1371.

The work in cooperation with the State Department of Farms and Markets, in planning drainage systems for the state-owned ditchers, has been continued. This work shows tangible results from a practical standpoint, and has educational value throughout the community. Members of the department have answered many calls for assistance on especially difficult drainage problems. In all cases the aim is to give this work a demonstrational value for other farmers, in addition to the individual benefit to those directly interested. The drainage of large muck areas has been continued.

Two assistant professors, A. M. Goodman and F. G. Behrends, have been added to the extension staff in the past year. The loss of Assistant

Extension Professor W. K. Blodgett through his resignation, which took effect on January 1, 1920, has been keenly felt.

Rural Social Organization

No systematic extension work has been attempted by the Department of Rural Social Organization, but addresses have been delivered at community meetings and some advice has been given through correspondence. A thorough study has been made of the best methods for work in rural organization and a project for extension work has been prepared.

Soil Technology

Demonstration work with soils has been somewhat reorganized with the idea of simplification. All demonstrations are now grouped under five subprojects. Two of these deal with the use of lime, one emphasizing its need on New York soils and the other comparing different forms and quantities of this material as a soil amendment.

Two hundred of these new lime demonstrations were planned in 33 counties of the State for the growing season of 1920. Because of delayed deliveries of lime, not more than one-half of these projects were started with spring crops. In addition to these new lime projects, a hundred or more of those established in 1918 and 1919 have been continued this year.

A project emphasizing the importance of phosphorus in soil utilization, and permitting of a comparison of different phosphatic materials as well as of acid phosphate with a mixed fertilizer, was outlined for this season. Twenty-five counties expressed their desire to establish this demonstration. A subproject demonstrating the proper treatment of the various soils of the State has also been outlined. This project has been established in several counties and will be taken up in others as rapidly as satisfactory cooperators can be found.

Another project, planned to emphasize the need of lime by means of a lime survey, has been started in five counties.

Lectures including extension schools, community meetings, farmers' institutes, and a few special assignments, have dealt largely with fertilizer and lime problems. Emphasis has been placed on the economic purchase of fertilizers, the importance of acid phosphate or other standard phosphatic materials for field crops, the value of farm manure and its proper utilization, and the relation of systematic liming to the improvement of the less productive soils of the State. Ten extension schools have been attended, covering a total of 35 days. Seventy-one additional lectures have been given, with a total attendance of 1774.

Besides the regular correspondence with farmers, special attention has been given to requests for expert advice from the various county managers.

Articles have been furnished regularly to the press and to the Farm Bureau News of the State through the Office of Publications. An attempt has been made to keep all farm bureau offices fully informed as to current fertilizer prices. A large number of soil samples have been examined and specific recommendations made for their future treatment.

Vegetable Gardening

Commercial vegetable growing, and school and home gardening, have been given attention by the Division of Vegetable Gardening during the year. One man devoted all of his time to school and home gardening; another devoted about two-thirds of his time to extension work in commercial gardening, and the remainder to tomato survey work.

In commercial gardening the main effort consisted in helping the county agents to arouse interest in demonstration work, through personal visits, conferences, and meetings. During the spring of 1920, demonstrations were started in most of the principal vegetable-growing counties. The most important of these were variety and strain demonstrations on tomatoes, cabbage, cauliflower, celery, and onions; plant-grading demonstrations on tomatoes, cabbage, and cauliflower; fertilizer and green-manure demonstrations on tomatoes; and fertilizer demonstrations on celery, lettuce, and onions grown on muck soils.

Assistance was given in the organization of county canning-crops associations and of a state canning-crops association with a membership of about 4000.

In school and home gardening extension, the main effort for the first three months of 1920 was the training of teams for demonstrations at fairs, and the supplying of subject-matter information to school-garden and crops-club leaders. Since January 1, 1920, the main work has been furnishing information to leaders through personal conferences, meetings, news articles, circular letters, and other means.

Recommendations

The past few years in extension work have constituted a period of growth. The work has not yet reached its highest development, but the time has come when it must be stabilized and coordinated. The specialists and the field forces need to be aligned more closely; the work should be limited to its proper sphere of teaching agriculture and home economics, and the organization should be so correlated as to reach a larger number of persons at less cost. This can be accomplished in part by the giving of advanced instruction to local leaders.

The quality of instruction must be improved to make it of maximum effectiveness. Special need exists for the increased use of illustrative

material, in the use of which many extension teachers are deficient. All the means of extension teaching — publications, lectures, demonstrations, exhibits, conferences, and the development of a real leadership by specialists and by the local workers — must be jointly developed.

The problem of the completion of the extension system still remains. Home demonstration agents are yet to be established in more than thirty counties. This will be done as fast as each new county is ready to cooperate in the maintenance of an agent. More than forty counties are still without junior extension leaders. Before the work in this field can be considered adequate, these leaders must be provided. The specialist service is not yet fully rounded; more specialists are needed in marketing, distribution, and economic problems, in dairying, in poultry husbandry, in animal husbandry, in rural organization, in plant diseases, in floriculture, in rural art, and in home economics. Additional finances must be provided either from federal or from state sources. The State and the Nation should feel and accept the obligation to complete the system which has been started and which has fully justified itself.

Difficulties are still found in obtaining trained and competent persons for extension service. To meet this need, courses in the College for the training of extension workers, especially county agents, should be made more complete. Students should be shown the advantages of work in this field.

The relocation and reorganization of the extension offices and office equipment to bring about a closer and more efficient physical and administrative relationship, reduce the overhead cost to a minimum, and provide for the most effective work, is urgent. Inadequate facilities extend throughout the Extension Service, and the best work will not be possible until adequate quarters and equipment are provided.

An additional helper in the editorial office to act as emergency editor on regular publications, and to prepare special material for the agricultural press of the State, is sorely needed. Publications are seriously delayed by the lack of editors. A further need in the Office of Publication is for a definite appropriation for the advertising of Farmers' Week in the winter and Farmers' Field Days in the summer. Such a fund should be available, also, to bring adequately to the people of the State, through the press, the advantages of the short course and the four-years course in agriculture.

THE RESEARCH ACTIVITIES

The legislation known as the Hatch Act, appropriating to the States funds to assist in the maintenance of agricultural experiment stations, was passed by Congress in 1887. In 1889 Cornell University was designated as the college entitled to receive the benefits of the act for New

York, and in 1894 the law was amended so that the New York Agricultural Experiment Station at Geneva should receive one-tenth of the funds. In 1906, by the Adams Act, additional federal funds were made available to the States for agricultural research. This grant was accepted by the New York Legislature in the same year, and the funds were applied to the maintenance of the Cornell University Agricultural Experiment Station and the New York Agricultural Experiment Station in the same proportion as the funds appropriated by the Hatch Act. In the Administration Act passed by the New York Legislature in 1906, the conduct of research is prescribed as one of the three coordinate lines of activity to be undertaken by the College.

The two institutions at Ithaca and Geneva are thus made jointly responsible for the solution of difficult agricultural problems. Accepting the responsibility, they have cooperated to avoid duplication of effort and to insure the best service. The State thus has one experiment station separated from teaching activities, where the workers, having no other responsibility than experimentation, may develop the best of experimental work habits; and another in which the activities of the workers may not be so concentrated, but in which the perspective is modified by the repeated organizing of subject matter for presentation to advanced students. It would seem that the two institutions might very effectively supplement each other in working out intricate and diverse agricultural problems. The possibilities of this have been materially furthered by the affiliation of the two stations, referred to elsewhere in this report.

The value to the State of an experiment station separated from all other activities cannot be questioned. The results obtained by the New York Agricultural Experiment Station at Geneva are of a high order, and the Station stands second to none as a leader in its field. The concentration on research and the comparative freedom from interruption have been productive of excellent work. There are many reasons, however, why an experiment station associated with the agricultural college is also necessary. The great need for more nearly complete knowledge concerning the fundamental nature of plant and animal responses and the laws of economics as applied to agriculture, would seem to justify the view that in the system of agricultural education the interests of sound research should have first consideration.

For the greatest development of research the aid of the teacher is required. In his efforts to better organize his subject, many problems will present themselves to the progressive teacher which might never come to the attention of one who works in research alone and who, by being separated from teaching activities, is not called upon to organize his subject critically. Not to give these men the equipment necessary

to conduct investigations on such problems is to greatly delay the development of a dependable system of agricultural knowledge. Furthermore, it is not easy to select men who will prove to be productive in research. Generally, among many, a few will prove especially effective.

Obviously, then, the larger the number of men in close touch with experiment stations, the greater will be the possibility of finding those who are peculiarly adapted to research efforts. If the large number of highly trained men necessary for teaching have not such equipment as an agricultural experiment station furnishes, many of great promise in research may never be permitted to discover their powers. If agricultural problems are to be solved, a constant stream of highly trained young men to enter upon research activities must be provided. These men must be trained at the colleges; if their teachers understand from actual experience the methods and difficulties of research and are animated by its spirit, young men with great possibilities for research will have their interest directed to it.

The experiment station is of great value to the college for its influence on undergraduate teaching. The research spirit is essential to the best teaching in any form of higher education. In an agricultural college it is peculiarly essential, because of the incompleteness of agricultural knowledge. In no agricultural subject are the resources of fact so complete that the teacher can give to his students a system of practices and be certain that all of those practices are, under all probable conditions, the best. The student in the classroom is thus repeatedly encountering unsolved problems, and he will encounter them after he leaves college. He must therefore be taught to evaluate the experimental evidence concerning the wisdom of different practices, not only in order that he may reach intelligent conclusions from the standpoint of evidence that is available when he is in college, but also that in his planning he may properly relate his own experiences after leaving college and new experimental evidence as it may appear.

It would seem undeniable that such a spirit of research could not be developed in students by teachers who do not have their own spirit of research constantly renewed and intensified by being associated with the conduct of research. It may fairly be maintained that the experiment station is the most vital feature in the system of agricultural education. It is not merely a continuing source of new truth, but also an effective agency in keeping alive in an institution the spirit of research — that attitude of mind which patiently examines the evidence before reaching a conclusion and is as essential to the honest presentation of truth as to its discovery.

The following is a brief report of the research activities of the different departments during the fiscal year 1919–20:

Agricultural Chemistry

In the Department of Agricultural Chemistry the following paper has been published:

F. E. Rice — Milk with high apparent acidity. Science 50: 424. 1919.

Individual cows were found giving milk with titratable acidities as high as 0.22 per cent. Formaldehyde titration indicated that where high casein was present high apparent acidity might be expected, although casein was not high in all cases of apparent high acidity. Titration by the Van Slyke oxalate procedure indicated that phosphates were always somewhat higher in this class of milk. Observations did not indicate that feeds were a factor in causing high apparent acidity.

The following paper is ready for publication:

F. E. Rice — A new conductivity cell.

The following work is under way:

G. W. Cavanaugh — Chemical studies of dairy wastes.
Mineral constituents of cattle feed.

F. E. Rice — Use of the apparatus for electrometric hydrogen ion determination as applied to milk and milk products.
The preservation of apple cider and other fruit juices.
A study of the organisms of sweetened condensed milk.

Agricultural Economics and Farm Management

In the Department of Agricultural Economics and Farm Management the following papers have been published:

J. E. Boyle — Collective bargaining in agriculture. Amer. Assoc. Agr. Legislation. Bul. 6:35-47. 1920.

This paper gives attention to the theory of collective bargaining and to its limitations and dangers. The experience in collective bargaining of a considerable number of groups of farmers is given.

Solving the problems in the new field. Univ. North Dakota. Quart. journ. 1920:329-335. 1920.

H. D. Phillips — Cooperative marketing in the Chautauqua-Erie grape industry. Cornell Univ. Agr. Exp. Sta. Mem. 28. 1919.

This memoir gives a rather minute history of the grape industry in the section considered, with particular reference to experiences in cooperative marketing. The difficulties encountered are reported from careful studies in the locality. Two general kinds of marketing organizations have been tried in the region: one, the small local type, and the other, the large central, or belt-wide, organization. The advantages and difficulties of both types are discussed.

G. F. Warren — Prices of farm products. Journ. farm economics 2:61-69. 1920.

This paper discusses the reasons for general high prices, and for the especially high prices of particular commodities. The question as to how long prices may remain high is considered.

W. I. Myers — An economic study of farm layout. Cornell Univ. Agr. Exp. Sta. Mem. 34. 1920.

This paper reports the results of a study of the layouts of fifty-three New York farms, the object being to trace the development of farm layouts, to study

the principles of efficient farm field arrangements, and to study the utilization of land on these typical farms with particular reference to the possibilities of increasing the area of crop land to meet the needs of an increasing population.

Plans are included illustrating different stages in the actual rearrangements of some New York farms as made by owners, and possible rearrangements of other farms which have been started but are not yet completed. These plans are accompanied by descriptions of the farms, of local conditions, and of the procedure followed in carrying out the plans for rearrangement.

A complete inventory of the land on these farms is given, showing the present use of all land. Data are presented comparing the use of land on these farms with that on the average New York farm, and also showing possible increases in the crop area of the farms studied by reclaiming land now unproductive and by utilizing for crops land which is now occupied by pasture or woods but which would be suitable for crop production. If the farms studied may be considered as typical, substantial increases can be made in the crop area of New York farms to meet the prospective needs of an increasing population.

The following papers have been mimeographed as a temporary report of studies being carried further:

G. P. Scoville — Results of farm management demonstrations in Dryden Township, 1909, 1919, comparisons.
Results of Niagara County farm management demonstration for the year 1919, comparisons made for the years 1913-1919.

The following papers are ready for publication:

J. E. Boyle — Speculation and the Chicago Board of Trade. (Book.)
Agricultural economics. (Book.)
Rural problems in the United States. (Book.)
E. G. Misner — An economic study of dairying on 149 farms in Broome County, New York.
C. V. Noble — The cost of living in a small factory town.
H. D. Phillips — Horse raising in colonial New England.

The following work is under way:

J. E. Boyle — Hay prices - coordination of factors of price, market arrivals, yields, acreage.
R. L. Gillett — A study of labor on farms.
E. G. Misner — A study of dairying on 166 farms in Herkimer County, New York.
W. I. Myers — An economic study of farm tractors in New York.
L. J. Norton — Cost of growing crops for canning factories.
G. P. Scoville — Potato production and prices.
G. F. Warren — Cost of producing farm products.
Prices of farm products.
Economics and the milk situation.
Agricultural surveys of Tompkins, Livingston, and Jefferson Counties.
E. C. Young — The movement of farm population.

Animal Husbandry

In the Department of Animal Husbandry the following paper is ready for publication:

M. W. Harper — Raising colts.

The following work is under way:

F. M. Fronda — Protein supplements for coconut oilmeal.
M. W. Harper (in cooperation with the United States Department of Agriculture) — The value of fish scrap as swine food.

E. S. Savage and L. A. Maynard — The rearing of calves on substitutes for skimmilk.
G. Toupin — The relation of amounts of vitamines in animal food to milk production and to the amount of vitamines in the milk.
H. H. Wing — Breeding work with dairy cows.

Botany

In the Department of Botany the following papers have been published:

O. F. Curtis — The upward translocation of foods in woody plants. I. Tissues concerned in translocation. Amer. journ. bot. 7:101-124. 1920.

The view has been held that carbohydrates move upward in the tree through the xylem. The author of this paper removed rings of bark from branches and removed the leaves above the rings. Analyses of the tissues above and below the rings were made, and both starch and sugar were present above the rings in greatly reduced quantities, if at all, until a new leaf surface had been formed. Even at the top of a ringed space a centimeter wide there was little or no starch in the sapwood tissues, though in the lower part of the ringed space starch might be present. When two rings were made on the same stem, one some distance above the other, the concentration of sugar in the xylem was much greater between the rings than above the upper one or below the lower one. It seems, then, that the sugar must be removed from the xylem in passing a strip a centimeter wide where the bark has been removed. This seems to show that upward translocation of carbohydrates is through the phloëm.

M. R. Ensign — Venation and senescence of polyembryonic citrus plants. Amer. journ. bot. 6:311-329. 1919.

Since it is apparently established that with some citrus species in which there are more embryos than one in a seed, one embryo is from the fertilized egg while the others arise from other tissue, the author of this paper thought that the seedling arising from the fertilized egg might show a greater rejuvenescence than the others, which in origin are more like plants from vegetative propagation. He used as a measure the size of vein islets as used by Benedict and the nucleo-cytoplasmic ratio in the root-cap cells. No differences were found among the seedlings, though some must have arisen from the fertilized egg and others from other tissue. The author holds that rejuvenescence is not more effectively brought about by sexual than by apogamous reproduction.

L. Knudson — Viability of detached root-cap cells. Amer. journ. bot. 6:309-310. 1919.

Root-cap cells of corn were alive at least forty-five days, and those of Canada peas at least seventy-one days, after they had been sloughed off into a sterile culture medium.

L. Knudson and E. W. Lindstrom — Influence of sugars on the growth of albino plants. Amer. journ. bot. 6:401-405. 1919.

Albino plants grown in Pfeffer's solution to which was added glucose or sucrose enough to make the solution 0.1 mol. or 0.2 mol. for sugar alone, while making slightly more growth than plants not receiving the sugar, yet made only slight growth before dying — seldom enough to equal the original seed weight. Chlorophyll-containing plants under the same conditions made considerably increased growth when sugar was supplied in the culture solutions.

L. Knudson and R. S. Smith — Secretion of amylase by plant roots. Bot. gaz. 68:460-466. 1919.

From work with plants in pure culture the conclusion is suggested that neither *Zea mays* L. nor *Pisum arvense* L. is capable of utilizing soluble starch, and that with neither is there an appreciable secretion of amylase by the roots.

D. Reddick and V. B. Stewart — Transmission of the virus of bean mosaic in seed, and observations on the thermal death point of seed and virus. Phytopathology 9:445-450. 1919.

Evidence is presented to show that the virus of bean mosaic is transmitted in the seed. Thus, seeds with the surfaces sterilized, either by washing in bleach-

ing powder, by washing in other sterilizing agents, or by heating to 70° C., in so far as they germinated produced plants a high percentage of which were infected. Experience indicated that the disease is not readily communicated from one plant to another.

L. W. Sharp — Spermatogenesis in Blasia. Bot. gaz. 69:258-268. 1920.

Some detailed observations on the origin of the male cell (spermatozoid) in Blasia, a liverwort, are given in this paper. Centrosomes were found present in Blasia at all stages of the mitosis which differentiates the androcytes. In the androcytes they were found to persist and function as the blepharoplasts. In the transformation of the androcyte into the spermatozoid, the blepharoplast fragments repeatedly by simple fission, forming a number of distinct granules which coalesce to form a short, lumpy rod. This rod elongates and becomes a more uniform thread bearing two cilia, while the nucleus also elongates in intimate union with it to form the body of the spermatozoid. The present instance is the first in which blepharoplast fragmentation has been reported in a bryophyte.

F. B. Wann — Fixation of free nitrogen by green plants. Science 51:247-248. 1920.

Seven species of grass-green algae were tested as to their ability to fix free nitrogen. All seven species seemed to show considerable ability to fix nitrogen when a small amount of glucose was present in the medium and when a definite amount of combined nitrogen was furnished in the form of ammonium nitrate or calcium nitrate.

K. M. Wiegand — Variations in *Lactuca canadensis*. Rhodora 22:9-11. 1920.

This is a study showing that forms of the wild lettuce usually ascribed to three species are simply leaf-variations of the same species due to environmental or inherent causes.

A new species of Spergularia. Rhodora 22:15-16. 1920.

The sand spurreys are salt-marsh plants but they occur also around salt springs in central New York. Those from near Montezuma and Savannah are unlike anything ever discovered elsewhere, and constitute a new species.

Eupatorium purpureum and its allies. Rhodora 22:57-70. 1920.

This is a study of the joe-pye weeds of eastern North America, showing that instead of these belonging to a single species there are actually four, and giving new means of recognizing them. Characters derived from the small florets were found especially useful.

The following papers have been prepared for publication:

E. Artschwager — On the anatomy of *Chenopodium album* L.
Studies on the pathological anatomy of potato blackleg.
O. F. Curtis — The upward translocation of foods in woody plants. II. Is there normally an upward transfer of storage foods from the roots or trunk to the growing shoots?
L. Knudson — Invertase secretion by roots of plants.
L. W. Sharp — Somatic chromosomes in Tradescantia.
K. M. Wiegand — Echinochloa in North America.
Additional notes on Amelanchier.

The following investigations are under way:

E. Artschwager — Studies on leaf roll diseases.
A. R. Bechtel — Anatomy of the flowers of the Urticaceae.
J. M. Brannon — Function of fructose and glucose in plants.
O. F. Curtis — Researches on conduction in plants.
Growth correlation in plants and inhibition of growth.
A. J. Eames —Anatomy of the Ranalian flower.
A. J. Eames and M. J. Fisher —Anatomy of the flowers of the Salicaceae.
H. E. Knowlton — Pollen viability.
L. Knudson — Organic nutrition of plants.
Orchid seed germination.
Enzyme production and fixation.
R. S. Nanz — Nitrogen fixation by legumes.

L. F. Randolph — Development of chondriosomes in relation to plastid inheritance in corn.

D. Reddick — Various phases of the bean mosaic problem.
Conditions of parasitism in maize.
A fourth Phytophthora disease of tomato.

L. W. Sharp — Studies on chromosome reduction.

F. B. Wann — Studies on the fixation of nitrogen by green plants.
Chromosome numbers in corn and development of embryosac.

K. M. Wiegand — North American species of oxalis.
Bromus ciliatus, B. secalinus, and their allies in North America.
Rudbeckia laciniata in North America.
Aster paniculatus and its allies in North America.

K. M. Wiegand and A. J. Eames — A catalogue and manual of the flora of the Cayuga Lake Basin.

Dairy Industry

In the Department of Dairy Industry the following papers have been published:

R. S. Breed and W. A. Stocking — The accuracy of bacterial counts from milk samples. New York (Geneva) Agr. Exp. Sta. Tech. bul. 75. 1920.

This publication gives the results of work conducted by the Department of Dairy Industry at Cornell and the Division of Bacteriology of the New York Agricultural Experiment Station at Geneva, primarily for the purpose of learning the best methods for determining the germ content of milk. This subject is of special importance at the present time because of the growing practice of using the germ content as a factor in determining the sale value of milk.

J. T. Cusick — Phosphorus in butter. Cornell Univ. Agr. Exp. Sta. Mem. 30. 1920.

This paper gives the results of a technical study of the amount of phosphorus in butter, especially in its relation to the development of fishy flavor. The author found that, in churning, about one-fourth of the phosphorus of the cream is retained in the butter. In storage the soluble organic phosphorus breaks down, giving inorganic phosphorus. The rate of this change is influenced by the treatment of the milk and cream before churning. The breaking down of one of these compounds, lecithin, to trimethylamine is the cause of fishy flavor in butter.

N. W. Hepburn —A modified Babcock method for determining fat in butter. Cornell Univ. Agr. Exp. Sta. Mem. 37. 1920.

This memoir reports an effort to find a simple but accurate method of determining fat in butter. The 9-inch, 9-gram, 90-per-cent bottles and the 6-inch, 6-gram, 90-per-cent bottles were found to be the most satisfactory types. From the standpoint of manipulation, the 9-inch, 9-gram bottle, permitting of a larger sample and better-spaced graduation, is the more desirable type. Such bottles, of course, can be used with the ordinary Babcock machines. A method is outlined for taking samples and preparing them for use in these bottles in the Babcock apparatus, by which, with 124 samples, results were obtained corresponding very closely to the results obtained by chemical analysis.

T. J. McInerney and H. C. Troy —A comparative study of some methods for determining the fat content of skimmilk. Cornell Univ. Agr. Exp. Sta. Bul. 401. 1920.

This bulletin reports modifications of the Babcock method, which make possible more accurate results in determining the percentage of fat in skimmilk.

G. C. Supplee — The lecithin content of butter and its possible relationship to the fishy flavor. Cornell Univ. Agr. Exp. Sta. Mem. 29. 1919.

The data given in this memoir indicate that there is in normal butter a sufficient amount of lecithin to yield on decomposition small quantities of trimethylamine, which substance is essential for the manifestation of the fishy odor. It is not considered, however, that the cause of the fishy flavor is satisfactorily established. A certain acid condition in the butter is essential, and also the presence of certain organisms.

H. C. Troy —A comparison of fat tests in milk as determined by a cow-testing association and by a creamery. Cornell Univ. Agr. Exp. Sta. Bul. 400. 1920.

This bulletin reports a study of the records of a cow-testing association and the tests of the milk from the same farms as it was delivered to the local receiving station. For some time the lack of agreement between such records has caused difficulty in some parts of the State. The results given in this study indicate that an exact comparison of the tests made by a cow tester and those made at the receiving station should not be expected, as there are so many factors which may very materially influence the relation between the two series of tests.

The following papers are ready for publication:

P. A. Downs — Bacterial flora of powdered milk.
G. C. Supplee, W. A. Whiting, and P. A. Downs — The influence of media and temperature on the plate count.

The following work is under way:

W. W. Fisk — The effect of washing curd on the yield and quality of cheddar cheese.
Relation of moisture and acidity to keeping quality of neufchatel and cream cheeses.
Factors affecting the formation of ice crystals in ice cream.
The effect of clarifying milk for making cheddar cheese.
Pasteurization of milk for cheese making.
The manufacture of Camembert, Swiss, and albumen cheeses.
E. S. Guthrie — Study of dairy plant records.
H. C. Jackson — The effect of neutralization on the quality of butter.
T. J. McInerney — Study of city milk supply.
Acidity of fresh milk.
H. E. Ross — Shipments of dairy products in New York State.
W. A. Whiting — Species of bacteria found in dairy utensils.

Entomology

In the Department of Entomology the following papers have been published:

C. P. Alexander — The crane-flies of New York. Part II. Biology and phylogeny. Cornell Univ. Agr. Exp. Sta. Mem. 38. 1920.

L. A. Hausman — The manipulation and identification of the free-swimming Mastigophora of fresh waters. Amer. nat. 54:333-348. 1920.

G. W. Herrick — The apple maggot in New York. Cornell Univ. Agr. Exp. Sta. Bul. 402. 1920.

This bulletin reports the results of experiments which clearly demonstrated that the apple maggot can be controlled by timely spraying with arsenate of lead, sweetened or unsweetened.

The winter of 1918–19 and the activities of insects with special reference to the clover leaf-weevil. Ent. Soc. Amer. Ann. 13:101-107. 1920.

The author's studies indicate that in the climate of central New York the clover leaf-weevil may survive during very mild winters and deposit eggs in the spring, thus producing a second generation.

W. N. Hess — The ribbed pine-borer. Cornell Univ. Agr. Exp. Sta. Mem. 33. 1920.

This memoir reports a study of the life history, economic importance, and means of control of the ribbed pine-borer.

Robert Matheson —A study of the plant lice injuring the foliage and fruit of the apple. Cornell Univ. Agr. Exp. Sta. Mem. 24. 1919.

This paper gives an exhaustive survey of the literature, together with the results of an extensive study of the life history and behavior, of the insects considered.

J. G. Needham — Burrowing mayflies of our larger lakes and streams. Bur. Fisheries. Bul. 36:269-290. 1920.

This is a discussion of the economic importance and the habits and classification of the insects treated.

The following papers are ready for publication:

Hazel E. Branch — Internal anatomy of Trichoptera.
P. W. Claassen — Typha insects: their ecological relationships.
E. H. Dusham — The painted hickory borer.
Laura Florence — The hog louse.
W. T. N. Forbes — The Lepidoptera of New York and the neighboring States.
H. H. Knight — Studies of the scarring of apples by insects.
J. T. Lloyd — Life histories of North American caddis flies.
C. F. W. Muesebeck — A revision of the North American species of ichneumon flies belonging to the genus Apanteles.
Helen E. Murphy — Metamorphosis of mayfly mouth parts.
Chih Ping — The biology of *Ephydra subopaca* Loew.
R. C. Smith — The biology of the Chrysopidae.
W. H. Wellhouse — The insect fauna of the hawthorns (Crataegus) and its relation to the apple orchard.
B. P. Young — The attachment of the abdomen to the thorax among Diptera.

The following work is under way in the department:

P. W. Claassen and Hazel Branch — A biological study of *Chironomus cristatus* and its relation to the disposal of milk waste.
J. D. Detwiler — Three little-known pests of clover.
Repugnatorial organs in notodontid caterpillars.
I. M. Hawley — Insect and other pests of beans.
G. W. Herrick — Some late summer caterpillars of the apple.
G. W. Herrick (in cooperation with the New York Agricultural Experiment Station at Geneva) — Experiments in the control of the apple and cherry maggots by dusting.
H. C. Huckett — Morphology of the ovipositor in the Anthomyiidae.
O. A. Johannsen — Parthenogenesis in certain dipterous insects.
Helen G. Mank — A contribution to the knowledge of Staphylinidae.
R. Matheson — A study of *Tetrastichus asparagi*, an important parasite of the asparagus beetle (*Crioceris asparagi*).
Insect vectors of plant diseases.
C. F. W. Muesebeck — Preparation of a host list of parasitic Hymenoptera.
Artificial biological control of certain injurious insects.
C. F. W. Muesebeck and R. Matheson — Rearing of local injurious insects to determine the parasitic forms that are factors in their natural control.
J. G. Needham and P. W. Claassen — Studies upon neuropteroid insects.
J. R. Traver — The life history of the black-nose dace (*Rhinichthys atronasus*).
R. L. Webster (in cooperation with the New York Agricultural Experiment Station at Geneva) — A study of the fumigation with hydrocyanic acid gas of deciduous fruit trees to control certain insect pests.
L. P. Wehrle — Insects affecting the seed of the clover plant.

Farm Crops

In the Department of Farm Crops the following papers are ready for publication:

E. V. Hardenburg — A study by the crop survey method of factors influencing the yield of potatoes.
R. G. Wiggans — A classification of the cultivated varieties of barley.

The following work is under way:

E. V. Hardenburg — Variety tests of beans and potatoes.
Strain tests of standard varieties of potatoes for different sections of New York State.

H. S. Mills (in cooperation with the Department of Farm Management) —A canning crops survey with reference to production cost and cultural methods.

E. G. Montgomery — Studies as to the best treatment and the value of pastures.

H. W. Schneck — Variety tests of forcing tomatoes.
Strain tests of Grand Rapids lettuce.
Training experiments with forcing cucumbers.

H. W. Schneck and A. C. Thompson — Pollination of forcing tomatoes.

H. C. Thompson — Strain tests of Danish Ball Head cabbage.
Strain tests of Bonny Best tomato.
A study of the effects of cultivation as compared with merely scraping the soil to keep down weeds, on the soil moisture supply and on the yield of several vegetable crops.
An experiment to determine the effects of pruning and staking tomatoes on yield, earliness, size of fruit, etc.
An experiment to determine the effects of removing suckers from sweet corn.

H. C. Thompson and R. W. Axt — Fertilizer experiments and plant-growing experiments with tomatoes.

H. C. Thompson and F. O. Underwood — Fertilizer experiments and variety and strain tests with muck crops.

R. G. Wiggans —A study of various rotations on continued production by soils of different types.
A study of silage corn and supplementary silage crops, especially sunflowers and soybeans.
Yield tests of various grass and clover mixtures.
Variety tests of corn, oats, wheat, clover, and alfalfa.

Floriculture

In the Department of Floriculture the following work is under way:

A. C. Beal — Variety studies with peonies.
Variety studies with garden roses.
Variety tests of winter-flowering sweet peas.
Variety tests of gladioli.

A. C. Beal and S. C. Hubbard — Crossing studies with garden roses.
A test of stocks for garden roses.

D. Lumsden-Orchid breeding.

Lua A. Minns — Species, types, and varieties of hardy primulas.

A. W. W. Sand — Variety tests of pogon irises.

C. L. Thayer — Variety tests of perennial phlox.

Forestry

In the Department of Forestry the following paper is ready for publication:

J. S. Everitt — Working plans for a communal forest for the city of Ithaca, New York.

The following work is being carried forward:

John Bentley — The factors influencing the growth and yield of forest trees.

Advanced students are making a study of sawmill costs.

Landscape Art

In the Department of Landscape Art the following work is being done:

R. W. Curtis —A study for the purpose of establishing a foliage key to landscape plants.

E. G. Davis —A study of the history of landscape art in England.

P. Porter — Landscape architecture: its relation and application to the rural schools of New York State.
A study of the ferns of New York State in their relation to landscape art.

Meteorology

In the Department of Meteorology the following work is under way:

W. M. Wilson — Studies in evaporation.
W. M. Wilson and others — The relation of the climate of New York to the agricultural industries of the State.

Plant Breeding

In the Department of Plant Breeding the following papers have been published:

R. A. Emerson — Pistillate-flowered maize plants. Journ. hered. 11:65-76. 1920.
This paper gives the results of a mendelian study of two types of corn bearing seed in the tassel.

C. H. Myers — The use of a selection coefficient. Amer. Soc. Agron. Journ. 12:106-112. 1920.
This paper gives the results of some selections with dent corn for high yield of mature ears. An adaptation of the ear-to-row method was followed. In selecting, a coefficient obtained by multiplying the yield by the percentage of ripe ears was used.

The following papers are ready for publication:

E. G. Anderson — Inheritance of salmon silk color in maize.
Sarkis Boshnakian — The relation of the spelt factor in wheat to rachis internode length.
The genetics of squareheadedness and of density in wheat.
R. A. Emerson — The genetic relations of plant colors in maize.
W. H. Eyster — Zigzag culm in maize.
A genetic study of the tunicate character in maize.
G. P. McRostie — Inheritance of disease resistance in the common bean.
C. H. Myers, H. H. Love, and F. P. Bussell — Production of new strains of corn for New York.

The following work is under way:

E. G. Anderson — Linkage studies in corn.
F. P. Bussell — Breeding barley.
F. P. Bussell, C. H. Myers, C. B. Hutchison, and R. A. Emerson — Breeding corn for grain and silage.
R. A. Emerson — Mendelian studies with corn, with special reference to linkage.
R. A. Emerson and G. P. McRostie (in cooperation with the Department of Plant Pathology) — Breeding beans for high yield and disease resistance.
A. C. Fraser — Mendelian studies with Aquilegia.
A. C. Fraser (in cooperation with the Department of Floriculture) — Breeding hardy roses.
C. B. Hutchison — Mendelian studies with flax and corn.
H. H. Love — Mendelian studies with wheat and oats.
The effect of selection within pure lines of beans and oats.
H. H. Love (in cooperation with the Cereal Office of the United States Department of Agriculture) — Breeding wheat, oats, and rye.
C. H. Myers — Breeding timothy.
Tuber-selection studies with potatoes.
Breeding cabbage.
The possibility of the inheritance of variations induced by differences in nutrition in wheat.

Plant Pathology

In the Department of Plant Pathology the following papers have been published:

W. H. Burkholder — The dry root-rot of the bean. Cornell Univ. Agr. Exp. Sta. Mem. 26. 1919.

This paper reports the results of laboratory studies of the fungus *Fusarium martii phaseoli* n. form., which causes the dry root-rot of the bean, together with inoculation studies and with studies concerning the effect of soil temperature on the growth of the fungus. It also reports the results of experiments to determine the extent of the reduction in yield caused by the disease, and efforts to control it by soil treatments and by securing resistant strains through breeding.

The effect of two soil temperatures on the yield and water relations of healthy and diseased bean plants. Ecology 1: 113-123. 1920.

The data given in this paper suggest that the Fusarium root-rot is about equally severe at a temperature of about 18° C. or at one of 26° C., though the bean plants grow more vigorously with the roots at the higher temperature.

H. M. Fitzpatrick — Rostronitschkia, a new genus of Pyrenomycetes. Mycologia 11:163-167. 1919.

E. M. Smiley — The Phyllosticta blight of snapdragon. Phytopathology 10:232-248. 1920.

Inoculation experiments and other studies of the organism *Phyllosticta antirrhini* Sydow, which causes a blight of the snapdragon, together with histological studies of the diseased tissue.

H. H. Whetzel — The present status of dusting. New York State Hort. Soc. Proc. 2:45-75. 1920.

This is a review of the results of experiments with dust spraying in the various sections of the country.

The following papers are ready for publication:

M. F. Barrus — Bean anthracnose.
C. Chardon — Pyrenomycetes of Porto Rico.
H. M. Fitzpatrick — Monograph of the Coryneliaceae.
E. F. Hopkins — The Botrytis blight of tulips.

The following work is under way:

M. F. Barrus — Investigations on some peculiar potato diseases.
F. M. Blodgett — Investigations into the nature and control of the leaf roll and mosaic diseases of potatoes.
O. C. Boyd — Diseases of potatoes.
W. H. Burkholder — Investigations on the bacterial blight of beans and other bean diseases.
C. Chupp — Investigations on the bacterial disease of the lima bean.
H. W. Dye — Investigations on the diseases of lettuce, particularly bottom rot and blights.
K. H. Fernow — Diseases of potatoes.
H. M. Fitzpatrick — Studies on the life histories and taxonomy of the Sphaeriales.
L. O. Gratz — Diseases of market garden crops, especially cabbage, eggplant, and potatoes.
R. S. Kirby — Root rot of corn.
L. M. Massey — Investigations on some diseases of gladioli and roses.
A. G. Newhall — Diseases of onions and lettuce.
F. R. Perry — A new disease of white pine.
S. P. Schlatter — Dusting for control of fruit diseases.
R. H. Vogel — Diseases of cabbage, cauliflower, and potatoes.
H. H. Whetzel — Continuation of work on Botrytis diseases of plants.
R. P. White — Blossom-end rot of tomatoes.

Pomology

In the Department of Pomology the following papers have been published:

D. B. Carrick — Resistance of the roots of some fruit species to low temperature. Cornell Univ. Agr. Exp. Sta. Mem. 36. 1920.

In a laboratory freezing chamber the smallest roots of French apple seedlings killed at a temperature of –10° C. or even higher, while the largest parts of seedling roots, one year old, killed at temperatures between –12 and –16° C.; this when the roots were the most resistant, in midwinter. Young roots of French pear seedlings and of Kieffer pear seedlings, and roots of sweet cherry, of Myrobalan plum, of Lindley, Norton, and Cynthiana grapes, of the blackberry, and of the red raspberry, were less resistant than those of the French apple seedlings, while roots of the Mahaleb cherry seedling, the Clinton, Concord, and Diamond grapes, the Wilder currants, and the Downing gooseberries were more resistant — roots of the Downing gooseberry withstanding a temperature of –20° C. Roots surrounded by soil seemed to kill at about the same temperatures as when surrounded by air. Roots were more resistant in a slightly wilted condition than when turgid.

W. H. Chandler — Some results as to the response of fruit trees to pruning. Soc. Hort. Sci. Proc. 16 (1919): 88–101. 1920.

It is reported in this paper that pruning either while dormant or during the growing period markedly dwarfs fruit trees. The dwarfing effect is much greater with young trees than with older ones. While pruning dwarfs the older trees, it appreciably increases the vigor at the growing points that are left. This increased vigor seems to result from the fact that fewer growing points are supplied with water and mineral nutrients from a root system that temporarily is not reduced. Root growth following pruning is relatively less rapid than top growth, however, and so this increased vigor is only temporary. With apples, pruning reduces the fruitfulness of young trees to a much greater extent than it dwarfs them. This does not seem to be true of plums, and is less striking with pears than with apples.

A. J. Heinicke — Concerning the shedding of flowers and fruits and other abscission phenomena in apples and pears. Soc. Hort. Sci. Proc. 16 (1919): 76–83. 1920.

This paper reports studies concerning the separation zone when the fruit falls; some characteristics of fruit doomed to fall; conditions that induce or hasten abscission; and conditions that delay or prevent abscission. The author seems to find that the causes which stimulate or excite the peculiar changes in this region are associated with variations in nutrition and water supply. If the tissue above the plane in which separation may occur is abundantly supplied with water and other substances that counteract maturity or favor translocation or utilization of assimilated material, conditions apparently are not favorable for manifestation of the meristematic nature of cells in the potential abscission zone.

The following paper is ready for publication:

H. A. Phillips — Effect of climatic conditions on fruit trees in relation to the blooming and the ripening dates, and the length of the growing period.

The following work is under way:

W. H. Chandler — The effect of the pruning necessary to secure various forms, on the leaf surface, growth, and fruiting habit of apples, pears, plums, quinces, cherries, and peaches.

The effect of pruning and of fruiting, especially seed production, on the amount of dry matter produced by a given leaf area, with apples, cherries, and grapes.

The relative response of gooseberries, currants, red and black raspberries, blackberries, young apple trees, and corn, when growing in the same soil, to applications of fertilizers.

The recovery of fruit trees from serious winter injury.

A. J. Heinicke — Factors that influence the abscission of flowers or young fruits.
Factors that influence the size and water supply of fruits.
Studies on the catalase activities of fruit-tree tissues.
The effect on fruit trees of possible secretions from grass roots.
The effect of different styles of pruning on the percentage of apple blossoms that set fruit.

A. J. Heinicke (in cooperation with the Department of Soil Technology) — The effect of grass on the nitrogen supply of fruit trees, and the response of the trees to variations in the nitrogen supply.

R. W. Rees — Variations in the internal structure of apples and pears as a possible means of identification.

Poultry Husbandry

In the Department of Poultry Husbandry the following paper has been published:

E. W. Benjamin — A study of selections for the size, shape and color of hens' eggs. Cornell Univ. Agr. Exp. Sta. Mem. 31. 1920.

The author of this paper concludes that the variability of a bird's production for a certain character does not depend on the difference existing between that bird's parents for the same character. It appears that small size and length of egg are dominant, while there seems to be no dominancy whatever for color. The type of egg incubated affects the mean type of egg produced during the life of the bird hatched, to a greater extent than it affects the pullet-year production or the production of any other single year.

A strong correlation exists between the types of eggs produced by individuals and the type of eggs from which these individuals were hatched. There is no correlation between the size and the shape of eggs produced by the birds used in this experiment. No definite tendency is shown toward a reduction of the variability of type of eggs produced by individual birds during successive years. During the pullet year the size of the eggs produced increases rapidly, but after the first year's production no appreciable change in the size of the eggs produced can be found. There seems to be no perceptible and consistent difference between the shapes of eggs laid by pullets and those laid by hens.

There is no gradual darkening of the shell pigment after the second year's production. Each year there is a tendency for the eggs produced to be more and more white during the first five or six months of production, and then to be more tinted again toward the end of the production season.

A distinct positive correlation is found between the size of the eggs incubated and the vigor of the respective chicks hatched, at various ages of the chicks; this correlation is especially significant during the period of severe weather conditions. There is a significant positive correlation between the size of the eggs incubated and the size of the respective chicks hatched; this correlation persists during the life of the birds as far as it was studied, that is, during a period of 228 weeks.

The following articles in trade journals are based on studies conducted in the department:

E. W. Benjamin — Handling of market eggs. (National poultry, butter, and egg bulletin.)

O. B. Kent — How to tell a laying hen. (Country gentleman.)
Methods of picking out the best laying hens. (Country gentleman.)
Characteristics of egg type. (Country gentleman.)
Definite plan of breeding for egg production with a minimum use of trapnests. (Reliable poultry journal.)
A practical judging system. (Reliable poultry journal.)
Trap-nest pedigree breeding for egg production. (Reliable poultry journal.)
Selecting roosters to increase production. (Cornell countryman.)

J. E. Rice — Influence of illumination on egg production. (Country gentleman.)
Artificial illumination as a factor in egg production. (Cornell countryman.)

The following work is under way:

Mavia Allen — Correlation of market-egg qualities with cooking values.
V. S. Asmundson — Relation of keel and pelvic bones to shape and production.
E. W. Benjamin — Determination of egg grades.
L. E. Card — Influence of season of hatching on egg production and cost.
G. F. Heuser — A study in the rate and method of digestion of feeds on egg production.
The effect of rations previous to hatching season on egg production, fertility, and hatching quality at the breeding season.
G. F. Heuser and J. E. Rice — Feeding pullets for egg production with artificial illumination.
O. B. Kent — Inheritance of fecundity.
The relation of physical characters to egg production.
Inbreeding.
Effect of cumulative selection on external characters.
Inheritance of comb type.
Comparison of breeds and varieties for egg production.
Relation between pigmentation of the parents and the hatching quality of eggs.
H. I. Macomber — Preservation of market eggs.
Causes of loss of eggs and poultry in transit.
J. E. Rice — Distribution of egg production.
The effect of illumination on production.

Rural Education

In the Department of Rural Education the following paper is ready for publication:

W. F. Lusk — The use of land in connection with the agricultural boarding schools of the South.

The following work is being carried forward:

J. E. Butterworth — Rural school finance.
Building scales for rural schools.
P. J. Kruse — Use of psychological tests as a basis of admission to college and of educational guidance.
R. M. Stewart — Inequalities of school support in Iowa.
G. A. Works, P. J. Kruse, J. E. Butterworth, T. H. Eaton, and O. G. Brim (in cooperation with workers from other universities) — A rural school survey of the State of New York.

Rural Engineering

In the Department of Rural Engineering the following work is under way:

J. C. McCurdy — Methods of subsurface irrigation for domestic sewage.
J. C. McCurdy and H. W. Riley — Engineering problems in the disposal of creamery sewage wastes.
H. W. Riley and F. L. Fairbanks — Implement draft.

Rural Social Organization

In the Department of Rural Social Organization the following work is under way:

D. L. Sanderson — The rural churches of Tompkins County.
W. S. Thompson — A study of the Sherwood community.
A study of the social relations of the rural schools in Tompkins County.

Soil Technology

In the Department of Soil Technology the following papers have been published:

T. L. Lyon, J. A. Bizzell, and B. D. Wilson — The formation of nitrates in a soil following the growth of red clover and of timothy. Soil science 9: 53–64. 1920.

Twelve cylinders capable of being leached were filled with a soil of medium fertility and good drainage qualities. The soil was abundantly limed and was fertilized with acid phosphate, muriate of potash, and dried blood. Six cylinders were planted to timothy and six to red clover. The soil of all cans was inoculated with *Bacillus radicicola* from clover nodules.

During the period when the timothy and the clover were growing, the soil was leached with distilled water from time to time. Nitrogen was determined in the drainage water and in the crops of timothy and clover. After these crops were removed the soil was allowed to remain in fallow for a month, and was then leached and nitrogen was determined in the drainage. Of the cylinders on which timothy had been grown, two were planted to oats and two to maize, and two were kept free of vegetation. The clover cylinders were treated in the same way. All were leached from time to time and nitrogen was determined in the drainage water and in the crops.

There was little difference in the quantities of nitrogen leached from the timothy soil and from the clover soil during the time when the two crops were growing on them. There was about six times as much nitrogen leached from the clover soil during the month when both soils stood fallow after the timothy and clover crops had been removed. There was only about twice as much nitrogen leached from the fallow clover soil as from the timothy soil during the next five months. At the end of this period the rate of nitrate production in the clover soil was little greater than that in the timothy soil. The crops of oats and maize following clover were larger, and contained more nitrogen, than those following timothy.

The experiment taken as a whole shows that, under the same conditions of soil and treatment, clover caused a greater production of available nitrogen than did timothy. This effect is shown in the nitrate content of the drainage water and the total nitrogen content of the oats and the maize. Whether the clover stimulated the nitrification process, or whether it contributed easily nitrifiable material, is not apparent from the data. If the greater production of nitrates in the clover soil was due to the decomposition of the residue of that crop, it appears that a part of this residue is more easily nitrifiable than dried blood, and that it constitutes only a small part of the entire residue of the clover crop.

R. A. Smith — Some effects of potassium salts on soils. Cornell Univ. Agr. Exp. Sta. Mem. 35. 1920.

In the experiments described in this memoir, potassium chloride decreased the accumulation of nitrates in all cases. Lime overcame this effect in part. Potassium sulfate apparently stimulated the accumulation of nitrates in Hagerstown and Dekalb soils.

The heavier potassium chloride treatments depressed nitrification of added materials. Potassium sulfate stimulated the process in all three soils with the exception of the heaviest treatment with Hagerstown soil. Lime had a tendency to correct the depression of the chloride in the Volusia soil, but did not entirely overcome it.

No iron nor aluminum was found in any of the water extracts, and no manganese was found in the extracts from the Volusia soil; hence the harmful action of the potassium salts cannot be attributed to replaced iron or aluminum, or to manganese in the case of Volusia soil. Both the chloride and the sulfate of potassium replaced calcium strongly. Less calcium appeared in the extract from the sulfate-treated series than would be expected, possibly because of the relative insolubility of calcium sulfate. Magnesium was replaced less strongly than was calcium. Manganese was replaced in very appreciable amounts in Hagerstown and Dekalb soil, particularly in the latter. The soil highest in

water-soluble manganese showed the least nitrifying efficiency, the smallest growth of wheat in pot cultures, and the poorest growth of wheat rootlets in extract cultures.

The effects of potassium salts on plant growth are due to a complex interaction of factors, involving perhaps the direct action of the salts on plant growth and on bacterial activities, and also the action of bases replaced by the potassium, particularly manganese.

H. W. Turpin — The carbon dioxide of the soil air. Cornell Univ. Agr. Exp. Sta. Mem. 32. 1920.

The results of this study indicate that the plant itself, and soil organisms, produce most of the carbon dioxide in the soil; that the plant often produces at the period of its most active growth many times as much carbon dioxide as is produced by soil organisms; and that the excess carbon dioxide in the soil growing a crop is due to respiratory activity of the plants rather than to the decay of root particles from the crop growing on the soil at the time of analysis.

A. F. Vass — The influence of low temperature on soil bacteria. Cornell Univ. Agr. Exp. Sta. Mem. 27. 1919.

When soils have been frozen there is sometimes an increase in the bacteria count as indicated by the agar-plate method. The author of this paper finds that this is due to the breaking-up of the clumps of bacteria, not to growth and multiplication. The results of some studies concerning factors that influence the resistance of bacteria to low temperature are also reported here, and a review of the literature concerning the killing of plant tissue by low temperature is given.

The following papers are ready for publication:

A. F. Gustafson — The effect of drying soils on the water-soluble constituents.
T. L. Martin — Decomposition of green manure at different stages of growth.

The following work is under way:

T. L. Lyon, J. A. Bizzell, B. D. Wilson, and E. W. Leland — Amount and composition of drainage water from soils, with special reference to the effect of liming and cropping.

T. L. Lyon, J. A. Bizzell, J. K. Wilson, A. J. Heinicke, and B. D. Wilson — The influence of higher plants on nitrogen transformation in soils.

T. L. Lyon, J. A. Bizzell, E. L. Worthen, and A. F. Gustafson — The composition and properties of certain soil types, and their response to fertilizers, lime, and plant growth.

This project includes the following purposes: to measure the nitrogen balance in soil under alfalfa and timothy grown continuously and under certain crop rotations; to ascertain whether the composition of a soil type, as now classified, is fairly uniform and characteristic; to ascertain whether the soil type, as now distinguished, is an index to the fertilizer needs of a soil; to test the availability of floats as influenced by farm manure, and to compare this carrier of phosphorus with acid phosphate by field trials; to compare the relative effectiveness as soil amendments of burned lime, limestone, marl, gypsum, dolomite, and magnesite, and of limestone ground to different degrees of fineness; to ascertain the effect on soil productivity of continuous cropping when the organic matter of the soil is maintained by means of seeded crops; to test various mixtures of fertilizer salts on different courses in a crop rotation as means of maintaining soil productivity; to test certain methods of soil management applied to Ontario loam and Volusia silt loam at different places in the State.

LIST OF PUBLICATIONS

The following publications of the College and Experiment Station have been issued during the year and distributed to the people of the State and to teachers and investigators in other States. They constitute part

of the annual report of the College and are issued separately as bulletins. Copies of any of these publications may be had on application to the Office of Publication, College of Agriculture, Ithaca, New York, so long as the supply lasts.

	Number of pages in printed publication	Number of copies printed
MEMOIRS:		
2 (Reprint) Action of certain nutrient and non-nutrient bases on plant growth (Department of Botany)	102	1,000
5 (Reprint) Physiological studies of *Bacillus radicicola* of Canada field pea (Department of Botany)	84	1,000
6 (Reprint) Fusaria of potatoes (Department of Plant Pathology)	188	1,500
8 (Reprint) A bacterial disease of stone fruits (Department of Plant Pathology)	64	1,000
10 (Reprint) A classification of the varieties of cultivated oats (Department of Farm Crops)	96	3,000
11 (Reprint) Biology of the Membracidae of the Cayuga Lake Basin (Department of Entomology)	276	1,000
18 (Reprint) A study of bacteria in ice cream during storage (Department of Dairy Industry)	40	1,000
28 Cooperative marketing in the Chautauqua-Erie grape industry (Department of Rural Economy)	94	4,000
29 The lecithin content of butter and its possible relationship to the fishy flavor (Department of Dairy Industry)	58	5,000
30 Phosphorus in butter (Department of Dairy Industry)	36	3,500
31 A study of selections for the size, shape, and color of hens' eggs (Department of Poultry Husbandry)	124	4,500
32 The carbon dioxide of the soil air (Department of Soil Technology)	50	4,500
33 The ribbed pine-borer (Department of Entomology)	19	4,500
34 An economic study of farm layout (Department of Farm Management)	181	8,000
35 Some effects of potassium salts on soils (Department of Soil Technology)	41	4,500
36 Resistance of the roots of some fruit species to low temperature (Department of Pomology)	54	4,500
37 A modified Babcock method for determining fat in butter (Department of Dairy Industry)	28	4,500
38 The crane-flies of New York. Part II. Biology and phylogeny (Department of Entomology)	600 (est.)	4,500
Total	2,135	61,500
EXPERIMENT STATION BULLETINS:		
353 (Reprint) The interior quality of market eggs (Department of Poultry Husbandry)	48	10,000
400 A comparison of fat tests in milk as determined by a cow-testing association and by a creamery (Department of Dairy Industry)	66	20,000
401 A comparative study of some methods for determining the fat content of skimmilk (Department of Dairy Industry)	20	7,000
402 The apple maggot in New York (Department of Entomology)	16	12,000
Total	150	49,000

	Number of pages in printed publication	Number of copies printed
READING-COURSE LESSONS FOR THE FARM:		
12 (Reprint) The improvement of the wood-lot (Department of Forestry)	24	1,000
72 (Reprint) Culture of the grape (Department of Pomology)	20	5,000
106 (Reprint) Spring in the flower garden (Department of Floriculture)	24	5,000
113 (Reprint) Judging draft horses (Department of Animal Husbandry)	32	3,000
114 (Reprint) Silos, and the production and feeding of silage (Department of Animal Husbandry)	24	5,000
115 (Reprint) Keeping sheep for profit (Department of Animal Husbandry)	24	5,000
117 (Reprint) Computing rations for farm animals (Department of Animal Husbandry)	68	10,000
121 (Reprint) The culture of garden roses (Department of Floriculture)	28	5,000
122 (Reprint) Planting the home vegetable garden (Department of Farm Crops)	24	5,000
123 (Reprint) Top-working and bridge-grafting fruit trees (Department of Pomology)	28	5,000
130 (Reprint) Rearing chickens: brooder house construction (Department of Poultry Husbandry)	32	10,000
133 (Reprint) Preparation of eggs for market (Department of Poultry Husbandry)	40	10,000
141 (Reprint) Farm manure: its production, conservation, and use (Department of Soil Technology)	32	5,000
147 Making advanced registry records (Department of Animal Husbandry)	28	35,000
148 The use of lime on the soil (Department of Soil Technology)	64	15,000
149 Principles of debate (Department of Extension Teaching)	24	15,000
150 Hog cholera (College of Veterinary Medicine)	20	40,000
151 Growing sweet peas (Department of Floriculture)	36	40,000
152 China asters (Department of Floriculture)	40	40,000
153 The country theater (Department of Extension Teaching)	20	40,000
154 The peony: a flower for the farmer (Department of Floriculture)	48	40,000
155 The country weekly in New York State (Department of Extension Teaching)	46	45,000
156 Incubation (Department of Poultry Husbandry)	40 (est.)	40,000
157 Feeding for egg production (Department of Poultry Husbandry)	56 (est.)	40,000
158 Locating the rural community (Department of Rural Social Organization)	36 (est.)	40,000
Total	858	504,000

READING-COURSE LESSONS FOR THE HOME:		
11 Reprint) The laundry (Department of Home Economics)	44	5,000
25 (Reprint) Saving strength (Department of Home Economics)	16	5,000
31 (Reprint) Household bacteriology (Department of Home Economics)	20	2,000
85 (Reprint) The arrangement of household furnishings (Department of Home Economics)	12	5,000

	Number of pages in printed publication	Number of copies printed
READING-COURSE LESSONS FOR THE HOME (*continued*):		
112 (Reprint) Short cuts for the home dietitian (Department of Home Economics)	44	1,000
117 (Reprint) Cereals in the diet (Department of Home Economics)	28	1,000
123 (Reprint) A program of thrift for New York State (Department of Home Economics)	8	50,000
124 (Reprint) Making a budget (Department of Home Economics)	12	50,000
125 (Reprint) Self-study outlines for promoting thrift (Department of Home Economics)	8	50,000
126 (Reprint) How to keep a cash account (Department of Home Economics)	8	25,000
127 (Reprint) What to spend for food (Department of Home Economics)	4	25,000
128 (Reprint) Points in selecting the daily food (Department of Home Economics)	8	25,000
129 (Reprint) Questions for group discussions on thrift (Department of Home Economics)	4	25,000
130 (Reprint) Club programs on thrift (Department of Home Economics)	16	25,000
131 Economics of a sound house (Department of Home Economics)	8	75,000
132 Economics of good furnishing (Department of Home Economics)	4	75,000
133 Use more cheese (Department of Home Economics)	20	75,000
Total	264	519,000
EXTENSION BULLETINS:		
10 (Reprint) Gladiolus studies — II. Culture and hybridization of the gladiolus (Department of Floriculture)	84	5,000
21 (Reprint) How to select laying hens (Department of Poultry Husbandry)	16	5,000
34 Extension work in agriculture and home economics in New York during 1918 (Department of Extension)	16	15,000
35 Composition of feeds (Department of Animal Husbandry)	2	15,000
36 Soil survey of Saratoga County, New York (Department of Soil Technology)	42	3,000
37 Soil survey of Oswego County, New York (Department of Soil Technology)	44	3,000
38 Better livestock in New York State (Department of Animal Husbandry)	12	25,000
39 Rural community conference (Department of Rural Social Organization)	88	5,000
40 The preparation of marketable vinegar (Department of Agricultural Chemistry)	14	10,000
Total	318	86,000
RURAL SCHOOL LEAFLETS:		
September, 1919 (Department of Rural Education)	64	25,000
November, 1919 (Department of Rural Education)	16	25,000
January, 1920 (Department of Rural Education)	50	150,000
March, 1920 (Department of Rural Education)	64	150,000
Total	194	350,000

JUNIOR EXTENSION BULLETINS:	Number of pages in printed publication	Number of copies printed
1 (Reprint) First lessons in sewing (Department of Home Economics)	44	10,000
2 (Reprint) Elementary garment making (Department of Home Economics)	28	10,000
3 (Reprint) Rearing the dairy calf (Department of Rural Education)	32	10,000
5 Raising pigs (Department of Rural Education)	34	5,000
6 Potato growing for boys and girls (Department of Farm Crops)	20	10,000
7 First lessons in food study (Department of Home Economics)	84	10,000
8 Corn growing for boys and girls (Department of Farm Crops)	20	5,000
Total	262	60,000
MISCELLANEOUS:		
Around the campus of the New York State College of Agriculture	28	3,000
Information for students	40	1,500
Program for thirteenth annual Farmers' Week, February 9–13, 1920	36	15,000
Program for Farmers' Field Days, June 30, July 1 and 2, 1920	16	5,000
Guide to a ride, Cornell campus and farms	32	3,000
Total	152	27,500
ANNUAL REPORT FOR 1919 (in two volumes)	2,230	2,000
ANNOUNCEMENTS		
Announcement of summer term, 1920	25	3,000
Announcement of courses, 1920–21	88	15,000
Announcement of winter courses, 1920–21	40	10,000
Total	153	28,000

SUMMARY

	Total number*	Total pages	Copies
Memoirs	18	2,135	61,500
Experiment station bulletins	4	150	49,000
Reading-course lessons for the farm	25	858	504,000
Reading-course lessons for the home	17	264	519,000
Extension bulletins	9	318	86,000
Rural school leaflets	4	194	350,000
Junior extension bulletins	7	262	60,000
Miscellaneous	5	152	27,500
Annual report	1	2,230	2,000
Announcements	3	153	28,000
	93	6,716	1,687,000

* Including reprints.

FINANCIAL STATEMENT, 1919-20

Fund	Original appropriation	Expenditures previously reported	Amount available or unexpended July 1, 1919	Receipts (Income and Smith-Hughes), 1919–20	Expenditures 1919–20	Balance: Lapsed	Balance: Unexpended June 30, 1920
State							
1918–19 Maintenance	$874,738.00	$801,687.24	$ 73,050.76		$ 22,858.84	$50,191.92	
1918–19 Game Farm	10,615.00	7,279.34	3,335.66		2,116.22	1,219.44	
1918–19 Deficiency	8,000.00	6,831.80	1,168.20		41.00	1,127.20	
1919–20 Maintenance	939,075.00		939,075.00		868,300.61		$70,774.39
1919–20 Game Farm	12,715.00		12,715.00		11,806.88		908.12
1919–20 Deficiency (fuel)	2,500.00	2,005.38	494.62		494.46	0.16	
1919–20 Deficiency (printing)	14,000.00		14,000.00		13,742.43		257.57
Total	$1,861,643.00	$817,803.76	$1,043,839.24		$919,360.44	$52,538.72	$71,940.08
Federal							
Morrill and Nelson	$ 20,000.00		$ 20,000.00		$ 20,000.00		
Hatch and Adams	27,000.00		27,000.00		27,000.00		
Smith-Lever	170,191.92		170,191.92		170,188.73	$3.19	
Smith-Hughes			*(1,824.19)	$18,822.61	21,663.78		* ($4,665.36)
Total	$217,191.92		$215,367.73	$18,822.61	$238,852.51	$3.19	* ($4,665.36)
Income							
Tuition and fees			$40,841.49	$ 93,566.75	$ 88,396.78		$46,011.46
Sales and services			25,539.77	183,973.88	195,097.59		14,416.06
Total			$66,381.26	$277,540.63	$283,494.37		$60,427.52
Grand total			$1,325,588.23	$296,363.24	$1,441,707.32	$52,541.91	$127,702.24

* Overdrafts on Smith-Hughes Fund covered by subsequent remittance from State Department of Education.

CONCLUSION

In submitting this report of the activities of the New York State College of Agriculture and the Cornell University Agricultural Experiment Station for the year 1919–20, I desire to record my great indebtedness for the able assistance of my associates, Dr. Cornelius Betten, the Vice Dean of Resident Instruction, Professor M. C. Burritt, the Vice Director of Extension, and Dr. W. H. Chandler, the Vice Director of Research, in its preparation.

Respectfully submitted,
A. R. MANN,
Dean and Director.

INDEX

INDEX

Index

Legislative Document **No. 45**

STATE OF NEW YORK

THIRTY-NINTH ANNUAL REPORT

OF THE

New York Agricultural Experiment Station

(GENEVA, ONTARIO COUNTY)

For the Year 1920

With Reports of Director and Other Officers

ALBANY
J. B. LYON COMPANY, PRINTERS
1921

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *January* 15, 1921.

To the Legislature of the State of New York:

As Commissioner of Agriculture, I have the honor to submit herewith the Thirty-ninth Annual Report of the Director of the New York Agricultural Experiment Station, at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

GEORGE E. HOGUE,
Commissioner.

NEW YORK AGRICULTURAL EXPERIMENT STATION

W. H. JORDAN, *Director*.

GENEVA, N. Y., *January* 15, 1921.

HON. GEORGE E. HOGUE, *Commissioner of Agriculture, Albany, N. Y.*:

DEAR SIR: I have the honor to transmit herewith the report of the Director of the New York Agricultural Experiment Station for the year 1920.

Yours respectfully,

W. H. JORDAN,

Director.

BOARD OF CONTROL

GOVERNOR ALFRED E. SMITH, Albany.
COMMISSIONER GEORGE E. HOGUE, Albany.
IRVING ROUSE, Rochester.
FRANK M. BRADLEY, Barker.
CHARLES C. SACKETT, Canandaigua.
CHARLES R. MELLEN, Geneva.
JOHN B. MULFORD, Lodi.
C. FRED BOSHART, Lowville.
PETER G. TEN EYCK, Albany.

OFFICERS OF THE BOARD

CHARLES R. MELLEN, *President.*

WILLIAM O'HANLON, *Secretary and Treasurer.*

STATION STAFF

WHITMAN H. JORDAN, Sc.D., LL.D., *Director.*

†ALBERT R. MANN, A.M., *Agricultural Economist.*
GEORGE W. CHURCHILL, *Agriculturist.*
REGINALD C. COLLISON, M.S., *Chief in Research (Agronomy).*
†T. LYTTLETON LYON, Ph.D., *Chemist (Agronomy).*
JAMES E. MENSCHING, M.S., *Associate in Research (Agronomy).*
JAMES D. HARLAN, B.S., *Assistant in Research (Agronomy).*
WILLIAM P. WHEELER, *Chief in Research (Animal Industry).*
ROBERT S. BREED, Ph.D., *Chief in Research (Bacteriology).*
HAROLD J. CONN, Ph.D., *Chief in Research (Soil Bacteriology).*
†WILLIAM A. STOCKING, JR., M.S.A., *Bacteriologist.*
GEORGE J. HUCKER, M.A.,
[1] JOHN W. BRIGHT, M.S.,
[2] MYRON W. FINCH, M.S.,
Assistants in Research (Bacteriology).
FRED C. STEWART, M.S., *Chief in Research (Botany).*
†DONALD REDDICK, Ph.D., *Botanist.*
WALTER O. GLOYER, M.A., *Associate in Research (Botany).*
[3] MANCEL T. MUNN, M.S., *Associate Botanist.*
[4] ELIZABETH F. HOPKINS, A.B., *Assistant Botanist.*
LUCIUS L. VAN SLYKE, Ph.D., *Chief in Research (Chemistry).*
RICHARD F. KEELER, M.S., *Associate in Research (Chemistry).*
RUDOLPH J. ANDERSON, Ph.D., *Chief in Research (Biochemistry).*
†LEONARD A. MAYNARD, Ph.D., *Biochemist.*
WALTER L. KULP, M.S., *Assistant in Research (Biochemistry).*
ARTHUR W. CLARK, B.S., *Associate Chemist.*
MORGAN P. SWEENEY, A.M.,
WILLIAM F. WALSH, B.S.,
[5] OTTO MCCREARY, B.S.,
Assistant Chemists.
MILLARD G. MOORE, B.S.,
[6] HAROLD H. WINSTON, B.S.,
[7] NATHAN F. TRUE, A.B.,
Assistant Chemists.
GEORGE A. SMITH, *Chief in Research (Dairying).*
[8] JAMES D. LUCKETT, M.S.A., *Editor and Librarian.*
[9] LAURA G. COLLISON, B.A., *Assistant Editor and Librarian.*
PERCIVAL J. PARROTT, M.A., *Chief in Research (Entomology).*
†GLENN W. HERRICK, B.S.A., *Entomologist.*
HUGH GLASGOW, Ph.D.,
*FRED Z. HARTZELL, M.A. (Fredonia),
Associates in Research (Entomology).
[10] ROSSITER D. OLMSTEAD, B.S.,
CLARENCE R. PHIPPS, B.S.,
[11] GUY F. MACLEOD, B.S.,
Assistants in Research (Entomology).
ULYSSES P. HEDRICK, Sc.D., *Chief in Research (Horticulture).*
†ROLLINS A. EMERSON, Sc.D., *Geneticist.*
†WILLIAM H. CHANDLER, Ph.D., *Pomologist.*
*FRED E. GLADWIN, B.S., (Fredonia),
ORRIN M. TAYLOR,
GEORGE H. HOWE, B.S.A.,
[12] RICHARD WELLINGTON, M.S.,
Associates in Research (Horticulture).
[13] EDWARD H. FRANCIS, M.A.,
[14] WILLIAM C. STONE, M.S.,
THEODORE E. GATY, B.S.,
[15] THOMAS O. SPRAGUE, B.S.,
[16] HAROLD B. TUKEY, M.S.,
Assistants in Research (Horticulture).
[17] JAMES S. LAWSON, Phm.B., *Museum Preparator.*
JESSIE A. SPERRY, *Director's Secretary.*
FRANK E. NEWTON,
WILLARD F. PATCHIN,
LENA G. CURTIS,
MAE M. MELVIN,
MAUDE L. HOGAN,
K. LORAINE HORTON,
Clerks and Stenographers.
ELIZABETH JONES, *Computer and Mailing Clerk.*

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

---

* Connected with Grape Culture Investigations.
† Members of the faculty of the New York State College of Agriculture affiliated with this Station.
[1] Resigned June 15, 1920.
[2] Appointed June 15, 1920. Resigned Dec. 30, 1920.
[3] Promoted July 1, 1920.
[4] Appointed July 1, 1920.
[5] Resigned Sept. 15, 1920.
[6] Resigned July 31, 1920.
[7] Appointed Dec. 1, 1920.
[8] Appointed Mar. 1, 1920.
[9] Appointed July 1, 1920.
[10] Resigned Sept. 30, 1920.
[11] Appointed July 1, 1920.
[12] Appointed July 1, 1920.
[13] Resigned Sept. 30, 1920.
[14] Resigned May 1, 1920.
[15] Appointed May 1, 1920.
[16] Appointed Oct. 1, 1920.
[17] Appointed July 1, 1920.

TABLE OF CONTENTS

Thirty-ninth Annual Report

of the

Board of Control of the New York Agricultural Experiment Station

TREASURER'S REPORT

Geneva, N. Y., *July* 1, 1920.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ended June 30, 1920.

1919	Receipts		
July 1.	To balance on hand		$5,078 37
	Salaries and labor (Albany)	$117,718 38	
	Repairs (Albany)	2,244 38	
	Adams fund	1,497 50	
	Hatch fund	1,488 19	
	Printing	400 00	
	Equipment and supplies	10,996 01	
	Fuel, light and power	5,833 28	
	Communication	2,200 00	
	Hired horses and vehicles	2,403 50	
	General plant service	750 00	
	Rent	650 16	
	Traveling expenses	3,000 00	
	Produce	4,549 59	
			153,730 99
			$158,809 36

EXPENDITURES

Salaries and labor (Albany)	$117,718 38	
Repairs (Albany)	2,244 38	
Adams fund	1,465 22	
Hatch fund	1,499 49	
Printing	393 65	
Equipment and supplies	11,233 82	
Fuel, light and power	6,068 86	
Communication	2,178 91	
Hired horses and vehicles	1,986 84	
General plant service	849 02	
Rent	580 50	
Traveling expenses	2,999 96	
Produce, remitted treasurer State of New York	4,549 59	
		$153,768 62
Balance on hand June 30, 1920		5,040 74
		$158,809 36
Balance Ring Memorial Fund		$1,244 95

All expenditures are supported by vouchers approved by the Auditing Committee of the Board of Control and have been forwarded to the Comptroller of the State of New York.

(*Signed*) W. O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1920 *

To the Honorable Board of Control of the New York Agricultural Experiment Station:

Gentlemen: — The time has again arrived when it is my duty and privilege to report to you the year's operations of the institution under your charge. This report will include a statement of the financial relations and of the pressing needs of the institution. As this is the last report which I shall have the honor of preparing for you, I desire to record my profound appreciation of the considerate and helpful attitude which your Board has uniformly maintained toward me during my entire period of service. It is fitting, too, that I should express my deep sense of obligation to the members of the staff with whom I have been associated for their generous and hearty cooperation in maintaining the work of the institution. In the letter of resignation which I addressed to you, I stated that "the measure of success which the institution has attained and the confidence which the people of the State appear to repose in it are due to the fidelity of my associates to their appointed tasks, their adherence to a sound interpretation of the true function of an Experiment Station, and their conservative attitude in their conclusions and public statements."

It is my most earnest wish that the institution shall continue to take its place among other Experiment Stations that adhere with a reasonable degree of faithfulness to the functions of a research institution. Before relinquishing the directorship it is my hope that I shall be able to prepare a resumé, in a somewhat popular form, of the results of Station work important to practical agriculture, which have been secured during the past 25 years.

ADMINISTRATION

STATION STAFF

Because of the re-adjustments following the disturbances in the staff due to the war, and because of the attraction offered by com-

* Reprint of Bulletin No. 483, December, 1920.

mercial interests and by other institutions, there have been rather an unusual number of resignations from the staff, necessitating an equal or greater number of appointments. The resignations are as follows:

William C. Stone, M. S., Assistant Horticulturist, resigned May 1, 1920, to enter into practical agriculture.

John W. Bright, M. S., Assistant Bacteriologist, resigned June 15, 1920, to take a position with a commercial company.

Harold H. Winston, B. S., Assistant Chemist, resigned July 31, 1920, to enter the employ of a commercial company.

Edward H. Francis, M. A., Assistant Horticulturist, resigned September 30, 1920.

Otto McCreary, B. S., Assistant Chemist, resigned Sept. 15, 1920, to accept a position in the State Experiment Station, Pullman, Washington.

Rossiter D. Olmstead, B. S., Assistant Entomologist, resigned Sept. 30, 1920, to accept a position with a manufacturing concern.

Myron W. Finch, M. S., Assistant Bacteriologist, resigned Dec. 30, 1920, to accept a position as a member of the staff of the University of Buffalo Medical School.

The loss of useful men who have become actively associated with the work of the Station has always been a matter of regret, but it is to be expected that the younger men of the staff when fitted for advancement which it is not possible to give them at the Station shall seek other positions offering larger remuneration or larger opportunities. It is, however, unfortunate that so many of our young men who give promise of usefulness in research or teaching are attracted by larger salaries to commercial activities.

The appointments are as follows:

James D. Luckett, M.S.A., graduate of Purdue University, was appointed Editor and Librarian on March 1, 1920. At the time of his appointment he was a member of the staff of the Office of Experiment Stations, United States Department of Agriculture. He succeeds Mr. Hall, who was obliged to relinquish his work on account of ill health. He has entered enthusiastically and effectively into service.

Thomas O. Sprague, B.S., graduate of the University of California, was appointed Assistant Horticulturist, May 1, 1920.

Myron W. Finch, M.S., graduate of Rhode Island State College of Agriculture and a graduate student of Brown Univserity, Providence, R. I., was appointed Assistant Bacteriologist, June 15, 1920. After remaining with us for a few months and having shown his ability, he was offered an attractive position at the Buffalo Medical School, which he accepted.

James S. Lawson, Phm. B., Museum Preparator, was appointed July 1, 1920. Part of the purpose of the new building recently erected at the Station was to house a museum which shall visualize the work which the Experiment Station has accomplished. Mr. Lawson entered upon this work July 1, 1920, and what he has already accomplished indicates not only the wisdom of his appointment but justifies the policy of developing a museum on the plan indicated.

Richard Wellington, M.S., graduate of Massachusetts Agricultural College and afterwards a graduate student of Harvard University where he was granted the degree of M.S., was appointed Associate Horticulturist, July 1, 1920. Mr. Wellington was formerly at this institution for five years, and later occupied positions in the Minnesota Experiment Station and Maryland University as Professor of Vegetable Gardening. He comes to the Station to meet the recognized need for taking up work in the field of genetics in an effort to make available the extensive results in plant breeding which have been secured during the past twenty-five years.

Harold B. Tukey, M.S., graduate of the University of Illinois, was appointed Assistant Horticulturist October 1, 1920.

Nathan F. True, A.B., graduate of the University of Maine, was appointed Assistant Chemist December 1, 1920.

Laura G. Collison, B.A., graduate of Ohio State University and afterwards a graduate student at Columbia University for one year, was appointed Assistant Editor and Librarian, July 1, 1920.

Elizabeth F. Hopkins, A.B., graduate of Vassar, was appointed Assistant Botanist, July 1, 1920, with specific reference to conducting seed investigations in the seed laboratory recently established at the Station.

Guy F. MacLeod, B.S., graduate of Massachusetts Agricultural College, was appointed Assistant Entomologist, July 1, 1920, under the special fund for Insecticides and Fungicides.

Mr. M. T. Munn, whose duties immediately relate to seed control was promoted from Assistant Botanist to Associate Botanist, July 1, 1920. This was done in recognition of efficient service for several years.

MAINTENANCE FUND

The expenditures of the Station during the fiscal year ended June 30, 1920, were as follows:

Personal service	$117,270 23
Maintenance and operation (including repairs)	37,535 83
Construction or permanent betterments	5,346 01
Total	$160,152 07

The Legislature of 1920 made the following appropriations for the use of the Station during the fiscal year beginning July 1, 1920:

Personal service:		
Salaries and wages	$148,150 00	
Salary of geneticist (special)	2,750 00	
		$150,900 00
Maintenance and operation:		
Fuel, light, power, and water	$7,000 00	
Printing	15,400 00	
Equipment and supplies	16,000 00	
Hired horses and vehicles	2,500 00	
Traveling expenses	3,000 00	
Communication	2,500 00	
General plant service	1,000 00	
Repairs	4,000 00	
Rent	500 00	
		51,900 00
Insecticide and fungicide investigations		5,000 00
Total		$207,800 00

The budget proposal for 1921–22 carries the following sums for the various needs of the institution:

Personal service	$176,975 50
Maintenance and operation	62,000 00
New construction and permanent betterments	85,000 00
Deficiency	700 00
Insecticide and fungicide investigations (re-appropriated)	3,008 33
Total	$327,683 83

INCREASES IN SALARIES

The management of the Station is highly appreciative of the action of the Legislature of 1920 in materially increasing the salaries of the

members of the scientific staff. Until the beginning of the present fiscal year, these salaries had remained practically on a pre-war basis. With the increases that were allowed, the salaries are not yet on a par with those paid to men of no greater ability in similar lines of work in the State. This is a discrimination against the members of the Station staff — not an intentional one, but one that has come about in the course of legislation. The budget proposals of this year suggest the bringing of these salaries up to a parity with those enjoyed by men in positions no more important and requiring no larger scientific training and ability.

NEEDED BUILDING EQUIPMENT

For several years, it has been my duty to call your attention to the fact that the plant houses at the Station, constructed some 30 years ago, and the small cold storage building, erected nearly as long ago, are in such a state of decay as imperatively to require their replacement by new structures if some important lines of work at the institution are to be continued. The public may not be aware that the modest request of $50,000 for forcing houses and cold storage facilities at the Experiment Station, a need which has existed for several years, was denied last winter, at the same time that millions were allotted to the College of Agriculture. This is said with perfect good feeling and in a spirit of rejoicing that the College has such a splendid future before it. If, however, this policy is likely to continue, the result will handicap agricultural progress. It will result in a top-heavy educational structure. All the knowledge we have which promotes the welfare of man has been acquired in two ways — experience and scientific research, and to the trained scientist and the modern laboratory we owe a large part of the methods and appliances which have made possible modern progress in agricultural methods. The value of research reaches out beyond the benefit to the farmer. It is of extreme importance to all the people because out of it have proceeded a more abundant supply of food, food of higher quality, and, above all, those sanitary measures which are such a remarkable defense against physical ills.

It is suggested here for your further consideration that following a policy which now seems to be acceptable to the Legislature of the State the Board of Control should prepare a program for the future

development of the institution. This policy has been accepted for the New York State College of Agriculture and for the development of the good roads system of the State. The Station should have new forcing houses, new cold storage, additions to the chemical laboratory to permit of proper scientific study of problems in animal nutrition, and other lines of enlargement or improvement which must be brought about if the Station is to continue to progress and to meet the increasing needs of the agriculture of the State. If such a program is presented to the Legislature and adopted, then the various needs will individually be met as fast as the finances of the State will appear to permit.

PUBLICATIONS

The Legislature of 1919 authorized the printing of two volumes, namely, "The Pears of New York" and "Sturtevant's Edible Plants of the World." The latter has been received from the printer. Under the terms of the law "any surplus copies over and above the number necessary for distribution to the members of the Legislature, educational institutions, libraries, and for exchange, shall be placed on sale by said Station to the public at cost, as determined by the State Printing Board." The Printing Committee has set the price of this volume at $2.75, which is about one-fourth or less than such a publication would cost if printed as a private enterprise. On receipt of this sum, payable to the New York Agricultural Experiment Station, volumes will be sent to individuals up to the limit of the supply.

The manuscript for "The Pears of New York" is not yet ready for the printer, and will not be for some months. This volume will not be distributed under a year, at least.

The mailing list, on the basis of which Station publications are now issued, is as follows:

POPULAR BULLETINS

Residents of New York	37,000
Residents of other states	2,558
Newspapers	735
Experiment stations and their staffs	2,284
Miscellaneous	350
Total	42,927

COMPLETE BULLETINS

Experiment stations and their staffs	2,284
Libraries, scientists, etc.	400
Foreign list	465
Individuals	4,150
Miscellaneous	350
Total	7,649

RESULTS OF STATION WORK IN 1920

DIVISION OF AGRONOMY

Soil fertility studies.— Bulletin No. 473 describes investigations made under greenhouse conditions in an effort to determine the effect of fertilizers upon the productiveness of soils from different parts of the State, and the influence of fertilizers and crop production on the soluble material of the soil.

Varying amounts of peat, stable manure, and commercial fertilizers were applied to nine different soils, each soil receiving the same treatment. Commercial fertilizers increased production to a much greater extent than did manure supplying the same amount of important plant food elements. The application of different combinations and amounts of commercial fertilizers to a highly productive soil and to a poor soil resulted in larger crop production on the latter than on the fertile soil.

When commercial fertilizers were added to an uncropped soil it was found that the proportion of soluble plant food elements was greatly increased, and was maintained at a high level for several months. However, soils which were producing crops showed a marked diminution of water soluble material even in the early stages of the growth of the crop. Before the plants had completed their growth, the water soluble ingredients of the soil were reduced to a level which was maintained during further growth. It was concluded, therefore, than an adequate supply of immediately available plant food is essential to successful crop production.

Commercial fertilizers in the orchard and vineyard.— Work on the fertility question in the orchard and vineyard has now been in progress for six to seven years and the results for this period have been published in a progress report as Bulletin No. 477. The investigation was originally planned as an extension of work already done on this question by the Horticultural Department. The

character of the results secured by this Department in the Station Rome Beauty Orchard made it very desirable to duplicate the work on other soils of New York fruit-growing sections.

The orchards reported on in the bulletin are as follows: Baldwin apple orchards near Albion and Rochester, a Northern Spy apple orchard near Fulton, a pear orchard near Kinderhook, and a cherry orchard near Geneva. The experiment also included a Concord grape vineyard near Fredonia in the Chautauqua grape belt and an apple nursery near Geneva.

In general, the results in the apple orchards have been very similar to the 15- to 20-year results with the Station Rome Beauty orchard. So far as yield of fruit is concerned, it has not paid to use commercial fertilizers on the Baldwin orchards under the system of management which these orchards have received. The Spy orchard is young and has shown some increase in trunk diameter due to fertilizers but what it will do as to yield remains to be seen. The cherry crop has been increased by fertilizers, especially by nitrogen but the increase has not paid for the cost of fertilization. In the vineyard, the indications are that nitrogen may be a limiting factor in this vineyard. In the nursery experiment, altho some interesting questions arose, fertilizers apparently did not make any better trees on the soil used.

Summing up the results to date, the indications are that on the better fruit soils of New York (and our orchards are on our better soils) commercial fertilizers will not pay financially in the best recognized system of orchard management, namely, that of clean cultivation and the use of cover crops. We must recognize, however, that there may be local conditions under which this statement would have to be modified, especially in the case of orchards in sod or on less fertile soil.

These experiments are being continued, and an endeavor will be made to render them still more comprehensive.

The perennial question of agricultural lime.— Considerable work has been done on this question in the past. The subject matter in Bulletin No. 478 comprises a brief summary of the main points to be remembered in the use of liming materials. Former bulletins can be consulted for more detailed information. The main object of the present bulletin is to make it easier for the farmer to secure these materials at the least cost. The bulletin contains an exten-

sive and quite exhaustive list of the manufacturers of agricultural lime in the State and also near the borders.

The extensive and increasing use of lime on land, together with the fact that transportation is a large factor in lime cost, make it very desirable that the farmer keep in touch with all sources of supply.

DIVISION OF ANIMAL INDUSTRY

Some studies relating to calcium metabolism.— Of the mineral elements serving in the bodies of all farm animals (as well as of man) calcium is found in largest amount. From the feeder's standpoint, also, it is one of the most important to consider because, under modern conditions, many rations fail to supply enough of this element. Most grain foods and some other foods, including many by-products, are deficient in calcium and contain much more magnesium than calcium, altho more calcium is required by the body.

Much calcium is required by the animal while its bones are hardening and by those mammals giving milk. During extended egg production by birds a large amount is needed. The obvious and somewhat exceptional demands for calcium by domesticated fowls while laying make them good subjects for certain studies relating to its metabolism.

The special physiological activities observed for one class of animals cannot be attributable in all particulars without qualifications to another class, but in a general way a knowledge of the influence of certain factors profoundly affecting the life of one warm blooded vertebrate may be used to help to an understanding of the needs of certain others.

Besides the special duties of the base-forming elements in the body, they all serve their part in maintaining neutrality wherever necessary. In this direction, magnesium, which is nearest to calcium chemically of any recognized element of the body or its food, works with calcium to a certain extent, altho in some important functions their action is antagonistic. But in the bony framework, in so far as it serves for mechanical support, and in the shells of birds' eggs, both structures having the two elements as normal constituents, it would seem that magnesium, much more abundantly supplied by many foods, might serve to a limited degree in place of lacking calcium. That it does this to an extent that can be

considered important or more than incidental or accidental we have failed to find.

On the other hand strontium was found capable of replacing calcium to a considerable extent in the egg shell and in bones as well as of accompanying or replacing calcium elsewhere in the body, altho it is not a recognized normal constituent of the body nor of ordinary foods.

Whenever rations deficient in calcium but carrying abundant supplies of magnesium were fed to the common fowl and the duck, there soon followed a noticeable shortage of calcium and of total mineral matter in the bones. With mature birds, whenever calcium was withdrawn from the skeleton it was usually taken in larger proportion from the softer bones.

With the duck, young and old, a fowl which seems better able to adapt itself to an excess of magnesium when only a very low indispensable minimum of calcium is present, the relations between the two classes of bones in respect to changes in composition did not hold always as with the common fowl. Where strontium replaced calcium in the bones, however, in every instance with both representative species, except in the earlier stages of feeding with immature birds, the ratio of strontium replacement was higher in the softer bones.

When strontium salts were fed for several weeks or several months with low calcium rations, mature hens or nearly mature chicks always had heavier bones with more mineral matter in them, actually and in relation to body weight, than did similar birds fed corresponding calcium or magnesium salts. There was a similar result when mature ducks were fed such rations for a limited time, but not with immature ducks or young ducklings or very immature chicks.

Under the unusual rations, of necessity largely used in such a study, the common fowl, on the whole, was much better able to endure the feeding of strontium salts than was the duck. On the other hand, the duck in these feeding trials showed greater tolerance for the excess of magnesium in rations of low calcium content than did the common fowl. The ability to save or to increase the stores of fat in the body under the unusual rations appeared to be considerably different for the two representative species.

Under the rations fed, the larger part of the calcium and of the total mineral matter used for egg production came sometimes from

the bones and sometimes directly and indirectly from the mineral salts fed.

The experiments which supplied the data above summarized were made at different times during a number of years as opportunity permitted, and have been reported in Bulletin No. 468 of this Station.

DIVISION OF BACTERIOLOGY AND DAIRYING

Physiological studies on milk secretion.— Technical Bulletin No. 80, on The Reaction of Milk in Relation to the Presence of Blood Cells and of Specific Bacterial Infections of the Udder, was published during the year in cooperation with the Division of Chemistry. In this bulletin the biological and histological data have been examined that have a bearing on the theory that the reduced H-ion concentration observed in fresh milk drawn from udders infected with long chain streptococci is caused by the entrance of blood serum into the milk during secretion. From the new data it appears that a more exact statement of the case would be that the bacterial infection causes the entrance of a serous exudate derived indirectly from the blood. This serous exudate is neither exactly like blood serum nor milk, but has a reduced H-ion concentration due to the predominance in it of the alkaline substances of the blood. With this serous exudate, there enter increased numbers of leucocytes and there is evidence also of increased wastage from the epithelial lining of the alveoli of the udder.

Laboratory methods for determining the sanitary quality of milk.— The final report of the cooperative analytical studies made with the Department of Dairy Industry of the College of Agriculture at Cornell has appeared during the year as Technical Bulletin No. 75 entitled The Accuracy of Bacterial Counts from Milk Samples. Aid has also been given in the preparation of the third edition of the Standard Methods for the Sanitary Analysis of Milk which was adopted by the American Public Health Association during the year. The year has seen a rapidly increasing use of the microscopic examination of milk as a means of determining the sanitary quality of fresh milk as delivered at the milk shipping and pasteurizing plants of the State.

Milking machine studies.— A report on results obtained by dairy farmers in producing sanitary milk where milking machines have been used, has been published as Bulletin No. 472 on The Produc-

tion of High Grade Milk with Milking Machines Under Farm Conditions. In this it is concluded that, altho the average dairy farmer is at the present time failing to keep his milking machines bacteriologically clean, methods are now known whereby it is easily possible for him to do so regardless of the type of machine in use. In comparing the bacterial count of over 16,000 samples of hand-drawn milk as brought into the Geneva city markets with the bacterial count of over 5,000 samples of machine-drawn milk it was found that the machine-drawn milk was received in much poorer condition. However, when two of the farms using machines were visited and the cleaning and operation of the milking machines done by a member of the Station staff, no difficulty was experienced in producing milk with a sufficiently low count to meet the standards for a grade A raw milk, i. e. official count less than 60,000 bacteria per cc.

Quality of milk received at cheese factories.— Studies have been made during the summer on the relation between the quality of patrons' milk at cheese factories and the quality of the cheese produced. A preliminary report discussing the relation or lack of relation between the number of bacteria in cheese factory milk and the quality and yield of the cheese is in preparation. Other studies on the influence of specific types of bacteria on the quality of cheese are in progress.

Control of city milk supplies.— Cooperation with the city of Geneva in the control of the city milk supply has been continued during the year. The object of the work is to find methods of controlling the quality of milk brought to the city that are effective and yet fair and just to the dairymen. Six years of records are now available from which to estimate the value of the work. A report on these is in preparation.

Pure culture studies of bacteria.— In many lines of bacteriological investigation it is necessary to make detailed studies of the individual kinds of bacteria in pure culture. This is necessarily laborious work which must often be continued for years before yielding results of value, and the difficulties are greatly increased by the lack of uniformity in the methods used by different bacteriologists. The Society of American Bacteriologists has for some time been working to obtain uniform methods of pure culture study and of descriptions of the bacteria, and for several years the Station has been cooperating in this work. One of the methods adopted to secure uniformity has

been thru the use of a printed chart for recording the characteristics of the organisms. During the past year this descriptive chart of the Society has been materially revised, largely on the basis of work done at this Station. It will soon be available and its use is expected to simplify certain investigations now under way. A further result of the cooperation with the Society has been a paper on Methods of Pure Culture Study, a revised report of the Committee on Bacteriological Technic, drawn up under the chairmanship of a member of the department.

Decomposition of manure.— The work previously reported on the ammonification of manure in soil (Technical Bulletin No. 67) is being followed up by a study of the decomposition of manure under conditions similar to those which occur in the manure pile. Different litters such as peat and straw and preservatives such as acid phosphate and gypsum are being studied as to their effects on the rate of decomposition, loss of nitrogen, and fertilizing value of the manure as judged by vegetation tests. This work is being done in cooperation with the Division of Agronomy.

Testing glassware.— The total number of bottles examined and marked under the law requiring Babcock glass graduation to be tested is given below.

TESTING OF BABCOCK GLASSWARE FROM DECEMBER 1, 1919 TO DECEMBER 1, 1920

10 per cent milk bottles	10,946
8 per cent milk bottles	15,955
30 per cent 6-inch, 18-gram cream	514
30 per cent 9-inch, 18-gram cream	744
40 per cent 9-inch, 18-gram cream	136
50 per cent 9-inch, 18-gram cream	1,107
50 per cent 6-inch, 9-gram cream	2,970
50 per cent 9-inch, 9-gram cream	324
60 per cent 6-inch, 9-gram cream	718
17.6 cc. pipettes	4,483
18 cc. pipettes	99
17.6 cc. up-to-date pipettes	95
17.6 cc. and 18 cc. pipettes	31
8.8 cc. pipettes	25
9 cc. pipettes	494
25 cc. pipettes	12
Acid measures	302
Acid bottles	4
Skim-milk bottles	290
	39,249
Rejections	452
Express packages	579

DIVISION OF BIOCHEMISTRY

A study of inosite phosphoric acids.— In Technical Bulletin No. 79 are described experiments which were made in efforts to synthesize phytic acid or inosite hexaphosphoric acid. Inosite hexaphosphoric acid could not be obtained but a new inosite phosphoric acid compound corresponding to the formula $C_6H_{12}O_{16}P_4$ was produced. The organic phosphorus compound of wheat bran was again investigated. After carefully purifying the substance crystalline barium salts were obtained corresponding to the formula $C_6H_{12}O_{24}P_6Ba_6$. A neutral silver salt having the composition represented by the formula $C_6H_6O_{24}P_6Ag_{12}$ was also prepared. It is evident, therefore, that the composition of the natural phytic acid is best represented by the formula of inosite hexaphosphoric acid, $C_6H_{18}O_{24}P_6$.

DIVISION OF BOTANY

The spacing of potato plants.— The experiments on the spacing of potato plants, which have been conducted at Geneva during five seasons, have been brought to a close and the results published in Bulletin No. 474. The chief purpose of these experiments was to determine the feasibility of employing close planting in the production of seed potatoes as a means of improving the quality of the crop thru a reduction in the average size of the tubers.

The experiments consisted chiefly of a comparison of 6- by 36-inch planting with 15- by 36-inch planting. Rows of thick and thin planting were alternated. The varieties used were Sir Walter Raleigh and Enormous No. 9. The soil was heavy clay loam of medium fertility. At harvest time the product of each row was sorted, according to weight, into four grades and the tubers of each grade weighed and counted.

The difference in net yield (total yield minus seed) of tubers over 1 ounce in weight varied, in different seasons, from 24.9 to 46.6 bushels per acre, and averaged 34.7 bushels per acre, in favor of thick planting. Over one-half of this difference (18.7 bushels) consisted of tubers over 2 ounces in weight. The average weight of tubers over 2 ounces in weight was reduced from 10.5 to 22.8 per cent by thick planting. For table use, the size of the tubers of the crop from thick planting was superior to that from thin planting

in two seasons, but in the other three seasons the tubers from thin planting were the better in this respect.

The results of the experiments appear to warrant the following conclusions: In the production of seed potatoes of varieties of the Rural group, New York growers may well consider planting considerably closer than 15 by 36 inches, since, thereby, the net yield is likely to be increased and the quality of the crop improved, particularly on rich soil. In the home seed-plat the spacing in the row should be as close as is consistent with roguing; but if the crop is to be sold the difficulty in disposing of the small tubers may necessitate somewhat thinner planting, except on rich soil. Potatoes grown in rich garden soil, for table use, may be planted as close as 6 by 30 inches with advantage.

Seed testing.— During the first half of the year the Seed Analyst of the Station made purity tests of 642 samples of seeds of which 267 were official and 375 unoffiical.

The new State seed law which went into effect July 1 requires that all agricultural seeds sold within the State shall be labeled in such manner as to show their purity and viability. The law applies to all of the common farm-crop seeds when sold in quantities of 10 pounds or more for seeding purposes whether in bulk, packages, bags, or other containers. In the case of special mixtures, such as lawn mixtures, quantities 8 ounces or over in weight must be labeled. The Station will continue to make free seed tests, under certain conditions, for the information of farmers; but for all tests the results of which are to be used for declarations of sale, a fee will be charged. Persons desiring information concerning the provisions of the new seed law and the rules governing the testihg of seeds should apply for Bulletin No. 476.

Under the new law 144 purity tests and 480 germination tests were made between July 1, 1920, and January 1, 1921.

DIVISION OF CHEMISTRY

The carbon dioxide content as a basis for distinguishing heated from unheated milk.— A study of the CO_2 content under conditions to which milk is subjected in the usual methods of handling shows that the CO_2 content is not appreciably affected by the method of milking, hand or machine; that the CO_2 content of milk rarely drops below 3 per cent by volume, when milk stands under ordinary

conditions, even for periods of from 20 to 40 hours; that the CO_2 content is not appreciably changed by passing thru a separator, and that only extreme and prolonged stirring reduces the CO_2 content below 3 per cent; that heating milk under the conditions required for pasteurization reduces the CO_2 content to, and usually below, 2.5 per cent by volume. Therefore, it is believed that when the percentage of CO_2 by volume is not more than 2.5 per cent, it is safe, in general, to assume that the milk has been heated to the temperature of pasteurization. The studies are described in Technical Bulletin No. 78.

Inspection of commercial fertilizers, 1920.— The total number of commercial fertilizers analyzed was 677, distributed as follows: 351 samples of complete fertilizers; 119 samples containing nitrogen and phosphoric acid; 58 samples containing phosphoric acid and potash; 72 samples of acid phosphate; 19 samples of bone; 8 samples of tankage; 15 samples of nitrate of soda; 7 samples of potash salts; 7 lime compounds; 15 samples of dried animal manures, mostly sheep; and 6 miscellaneous samples. The results of the analyses are reported in Bulletin No. 480.

Inspection of insecticides and fungicides, 1920.— The total number of samples analyzed was 195, distributed as follows: 19 samples of paris green; 46 samples of lead arsenate; 9 samples of calcium arsenate; 18 samples of bordeaux mixture; 5 samples of bordeaux-paris green mixtures; 18 samples of bordeaux-lead arsenate mixtures; 13 samples of lime-sulphur solution; 6 samples of dry lime-sulphur preparations; 9 samples of nicotine preparations; 7 samples of soap; 6 samples of hellebore; and 39 miscellaneous samples. The results of the analyses are reported in Bulletin No. 481.

Inspection of feeding stuffs, 1919.—The total number of samples of feeding stuffs analyzed was 1610, distributed as follows: 27 samples of alfalfa meal; 76 samples of animal products; 42 samples of barley by-products; 11 samples of brewers' dried grains; 22 samples of buckwheat by-products; 33 samples of calf meal and pig meal; 6 samples of cocoanut meal; 376 samples of compounded feeds; 262 samples of compounded feeds containing molasses; 23 samples of corn gluten feed and meal; 48 samples of corn meal and corn feed meal; 12 samples of corn, oats, and oat by-products; 100 samples of cottonseed feed and meal; 7 samples of distillers' dried grains; 5 samples of dried beet pulp; 58 samples of hominy feed and meal; 28 samples

of linseed meal; 4 samples of malt sprouts; 16 miscellaneous samples; 7 samples of feeding molasses; 15 samples of oats and oat by-products; 4 samples of peanut feed; 174 samples of poultry feeds; 17 samples of rye products; 11 samples of wheat and corn products; 6 samples of wheat and rye products; 88 samples of wheat bran; 35 samples of wheat bran and middlings; 3 samples of wheat bran and low-grade wheat flour; 85 samples of wheat middlings; 5 samples of wheat middlings and low-grade flour; 4 samples of dried yeast grains. The results of the analyses are reported in Bulletin No. 469.

Inspection of feeding stuffs, 1920.—The total number of samples of feeding stuffs analyzed was 871, distributed as follows: 13 samples of alfalfa meals; 53 samples of animal products; 7 samples of buckwheat by-products; 21 samples of calf meal and pig meal; 5 samples of cocoanut meals; 203 samples of compounded feeds; 104 samples of compounded feeds containing molasses; 28 samples of corn gluten feeds and meals; 17 samples of corn meal and corn feed meal; 5 samples of corn, oats, and oat by-products; 42 samples of cottonseed feeds and meals; 5 samples of dried beet pulp; 30 samples of hominy feeds and meals; 23 samples of linseed meals; 20 samples of miscellaneous materials; 5 samples of oats and oat by-products; 114 samples of poultry feeds; 7 samples of rye products; 7 samples of wheat and rye products; 51 samples of wheat bran; 27 samples of wheat bran and middlings; 2 samples of wheat bran and low-grade wheat flour; 9 samples of wheat bran, wheat middlings, and low-grade flour; 64 samples of wheat middlings; and 9 samples of wheat middlings and low-grade flour. The results of the analyses are reported in Bulletin No. 482.

DIVISION OF ENTOMOLOGY

The leafhopper as a potato pest.— The leafhopper (*Empoasca mali* Le Baron) has derived its reputation as a destructive agent chiefly from its injurious activities on young apple trees. Recently it has been the subject of special study with regard to its economy as a potato pest. The facts reported in Technical Bulletin No. 77 have established an important injurious relationship to potato culture in New York.

Migration of over-wintering leafhoppers to potato plantings began during early June, and the vines were sought for purposes of oviposition as soon as they appeared above the ground. Eggs were

deposited largely in the young tender leaves near the growing tips of the plants and oviposition continued until the plants were killed by frosts during early October. With the hatching of the nymphs all stages of the pest were present on the vines during the growing period.

In cage and field experiments feeding by the insects produced small, brownish areas of one-fourth inch or more in width at the tips and occasionally on the margins of the leaflets. The injury became more conspicuous as the season advanced, the brownish or burned areas increasing both in extent and numbers. As tissues became desiccated the margins rolled over the upper surface, leaving a small narrow green area in the central portion of the leaflet.

The disorder attained its greatest intensity during August. At this period nymphs and adults of the second generation of the leafhopper became increasingly abundant and intermingled with them were individuals of the different stages of the first generation. Feeding by both nymphs and adults was attended with injuries to leaf structures.

Insect injuries in relation to apple grading.— In the practice of grading fruit according to the provisions of the New York Apple Grading Law the attention of the fruitgrower has quite naturally been called to the great variety and diverse character of the insect injuries appearing on the fruit at picking time. This has led to an unusual number of demands on the Station for information in regard to the agents responsible for blemishes on the mature apples. The orchardist can readily see the value of greater knowledge on his part concerning the distinguishing marks of the various insect injuries which are, in many cases, quite characteristic and often more conspicuous than the insect itself. When he has once learned to recognize the various defects he can easily tell which insects are least under control in his orchard and can modify his spraying practices accordingly.

In Bulletin No. 475 the species of insects that attack apple fruits are described and grouped according to the injuries they produce.

A key for the identification of the different species is included and permits ready recognition of both insects and typical malformations.

Certain aspects of the subject which have received special consideration are activities of insects on fruit after harvest, effect of

insect injuries on yield, and defects of apples which may be confused with insect injuries.

Methods for combating the individual insects are indicated. In the main, the destructive agents are efficiently and economically treated by a routine system of spraying for which directions are given.

DIVISION OF HORTICULTURE

Studies on the cost of producing grapes.— Information has been accumulated in Bulletin No. 479 regarding the cost of producing grapes in three widely separated vineyards of the Chautauqua and Lake Erie fruit belt for the period of 1915 to 1919, inclusive.

Data are presented which show the amounts expended for maintenance, labor, and harvesting for each vineyard as well as for each acre cultivated and for each ton of grapes produced. The net return per acre and per ton is estimated for each year of the investigation.

The average cost of production for the three vineyards during the five years was $74.13 per acre, and the average cost per ton of grapes was $40.58.

The average net profit per acre was found to be $66.64. and the average profit per ton $26.31.

It is concluded that under intensive management the growing of grapes in this region can be made profitable, in spite of the high cost of labor and supplies, providing the selling price of the crop is maintained at or near the level of the 1918 and 1919 seasons.

Asexual inheritance in the violet.— In the improvement of fruit varieties the question of fixity of type in asexual propagation is of very considerable importance. The use of any of the tree fruits in a study of this problem would obviously extend the experiment far past the activity of a single investigator. In order to hasten work on this question the double violet, Marie Louise, which is propagated asexually, was used in a study of the effect of selection upon the length of blossom stem. Observations were also made of the inheritance of high and low yield. The investigation is described in Technical Bulletin No. 76.

At the end of five years it was found that: The process of selection has really been one of isolation whereby certain clonal lines have been selected out of a miscellaneous population. We seemingly

have proved only the existence of asexually inherited differences which probably were present before the experiment was begun. No attempt has been made to find when or how such differences arose.

Tho the existence of such differences in the violet makes it seem more probable that there may be differences within a single variety of any fruit, the labor and the technical difficulties involved render it inadvisable for a nurseryman to attempt to find beneficial variations among fruits by bud selection.

PUBLICATIONS ISSUED DURING 1920

BULLETINS

No. 471. January. Some of the effects of the war upon fertilizers. L. L. Van Slyke. Pages 10. Distributed June 14, 1920.

No. 472. February. Milking machines: V. The production of high grade milk with milking machines under farm conditions. J. W. Bright. Pages 27. Figs. 9. Charts 5. Distributed June 21, 1920.
Popular edition. Pages 13.

No. 473. March. Soil studies: I. The influence of fertilizers upon the production of several types of soil. II. The influence of fertilizers and plant growth upon soil solubles. W. H. Jordan. Pages 27. Distributed November 20, 1920.
Popular edition. Pages 18.

No. 474. April. Experiments on the spacing of potato plants. F. C. Stewart. Pages 32. Distributed November 20, 1920.
Popular edition. Pages 6.

No. 475. May. Insect injuries in relation to apple grading. B. B. Fulton. Pages 42. Plates 4. Charts 2. Figs. 17. Distributed June 1, 1921.

No. 476. June. The New York seed law and seed testing. M. T. Munn. Pages 28. Figs. 4. Distributed November 20, 1920.
Abridged edition. Pages 15.

No. 477. June. A progress report of fertilizer experiments with fruits. R. C. Collison. Pages 53. Figs. 6. Distributed November 20, 1920.
Popular edition. Pages 11.

No. 478. June. Sources of agricultural liming materials. R. C. Collison. Pages 14. Distributed November 20, 1920.

No. 479. September. Studies on cost of producing grapes. F. E. Gladwin. Pages 33. Distributed May 4, 1921.
Popular edition. Pages 7.

No. 480. October. Inspection of commercial fertilizers, 1920. Pages 59. Distributed May 25, 1921.

No. 481. December. Inspection of insecticides and fungicides. Pages 18. Distributed May 25, 1921.

No. 482. December. Inspection of feeding stuffs, 1920. Pages —. Distributed ————.

No. 483. December. Director's report for 1920. W. H Jordan. Pages 23. Distributed May 25, 1921.

TECHNICAL BULLETINS

No. 75. January. The accuracy of bacterial counts from milk samples. R. S. Breed and W. A. Stocking. Pages 97. Distributed June 25, 1920.

No. 76. March. Asexual inheritance in the violet (*Viola odorata*). R. D. Anthony. Pages 55. Charts 10. Distributed November 20, 1920.

No. 77. March. The leafhopper as a potato pest. P. J. Parrott and R. D. Olmstead. Pages 18. Plates 5. Distributed November 20, 1920.

No. 78. March. The carbon dioxide content as a basis for distinguishing heated from unheated milk. L. L. Van Slyke and R. F. Keeler. Pages 7. Distributed June 25, 1920.

No. 79. May. Concerning inosite phosphoric acids: I. Synthesis of phytic acid. II. Composition of inosite phosphoric acid of plants. R. J. Anderson. Pages 22. Distributed November 20, 1920.

No. 80. July. The reaction of milk in relation to the presence of blood cells and of specific bacterial infections of the udder. J. C. Baker and R. S. Breed. Pages 19. Distributed November 20, 1920.

W. H. JORDAN.

NEW YORK AGRICULTURAL EXPERIMENT STATION,
GENEVA, N. Y., *January* 15, 1921.

REPORT

OF THE

Department of Agronomy

W. H. Jordan, *Director.*

R. C. Collison, *Chief in Research* (*Agronomy*).

J. E. Mensching, *Associate in Research* (*Agronomy*).

J. D. Harlan, *Assistant in Research* (*Agronomy*).

TABLE OF CONTENTS

REPORT OF THE DEPARTMENT OF AGRONOMY

SOIL STUDIES *

W. H. JORDAN†

SUMMARY

RESULTS WITH FERTILIZERS ON NINE SOILS

1. Experiments have been conducted under forcing house conditions with nine soils, taken from as many localities in the State.

2. Peat, stable manure, and commercial fertilizers were applied to these soils in varying proportions, each soil receiving the same treatment.

3. The production with commercial fertilizers was much larger than with stable manure containing the same quantities of nitrogen, phosphorus, and potassium as the commercial mixture.

4. The yields of dry substance increased with increasing applications of fertilizers, but not in the same proportion.

5. The application of lime with stable manure caused a very irregular effect in the growth of the barley plant. In four soils, the increased growth over stable manure alone was large; with three, there was a manifest advantage; and with two, there was an apparent injury.

RESULTS WITH FERTILIZERS ON TWO SOILS

6. Commercial fertilizers were applied in different combinations and in unlike quantities to two soils, one a highly productive soil from the Station farm, and one a soil from a region known as Pine Plains, regarded as inferior for crop production, each soil receiving similar treatment in all respects.

7. Under forcing house conditions, the Pine Plains soil produced larger crops than the soil from the Station farm.

8. The production of barley dry substance increased with the increased application of fertilizers, but not proportionately.

---

* Reprint of Bulletin No. 473, March, 1920.

† The chemical analyses required for the data given in Bulletins 465 and 473 were performed by E. B. Hart, E. L. Baker, and M. P. Sweeney, to whom acknowledgments are hereby made.

9. Nitrogen was the only ingredient of the commercial fertilizers which had any marked influence upon the growth of the barley plant. Under forcing house conditions, the soils appeared to supply sufficient quantities of phosphorus and potassium for luxuriant growth.

A STUDY OF WATER SOLUBLES

10. A study was made of the influence of commercial fertilizers and plant growth upon the water solubles in the eleven soils used in these experiments.

11. When soluble commercial fertilizers were added to these soils it was found that in most instances where the soils did not support plant growth, the proportion, especially of nitrogen and potassium water solubles, was greatly increased and was maintained on essentially the same level during a period of several months.

12. With the nine soils, the proportions of water solubles after the production of two crops were greatly less than in the soil before the plants were grown.

13. With the Station soil and the Pine Plains soil, the plant growth, even in the earlier stages, caused a marked diminution of water solubles.

14. Before the plants had completed their growth, the water solubles were practically reduced to a level which was maintained during the further growth.

INTRODUCTION

The soil and its relation to plant production present what are perhaps the most complex and many-sided problems of any with which agricultural science has to deal. These problems must be approached from many angles, including those with which the biologist, the chemist, and the physicist have to deal. As seems to be indicated by the data presented in Bulletin No. 424, we are not yet able to measure the fertility of any given soil through chemical methods. It is desirable, however, to learn as much as possible concerning the reactions upon the soil of the addition of commercial fertilizers and the effect of plant growth upon the soil status.

In an effort to add something of a contribution to the conditions related to plant growth, there has been made during a series of years a study of the following questions:

1. The influence of chemical fertilizers upon the productiveness of several types of soil.

2. The effect that the application of chemical fertilizers has upon the soil content of compounds soluble in certain media.

3. The influence of plant growth upon the soil content of compounds soluble in certain media.

As a means of studying these questions, the following projects were undertaken:

1. Forcing house vegetation experiments with nine different types of soil to which were added chemical fertilizers in varying amounts. These experiments were continued thru two seasons, using the same soils and the same portions of each soil.

2. Forcing house vegetation experiments with two soils, receiving these chemical fertilizers in different combinations and different amounts.

3. The determination of water solubles in nine different soils to which chemical fertilizers have been applied in different amounts.

4. The determination of the soluble content of the same soils after the growth of a crop of barley.

5. A study of the effect of plant growth thru a series of examinations of the water soluble content of two soils on which no plants were grown and of the several soils from which barley was harvested at various stages of growth.

PRODUCTION EXPERIMENTS

Methods and Results with Nine Soils

The soils.— The nine soils used in this experiment were those described in Bulletin No. 424, and for the sake of convenience the descriptions are repeated here:

No. 1894.— A brown or yellow sandy loam, six to ten inches deep, resting on yellow or gray sandy loam and gravel. It contains flat shale and a few glacial erratics. It is of glacial origin. It is a good soil for corn, oats, and potatoes. It is found in Chautauqua and Tompkins counties. The sample was collected on the farm of D. H. Hopkins, four miles northwest of Ithaca, N. Y. The field was corn stubble, fertilized the previous year with fifteen loads of sheep and hog manure per acre. No commercial fertilizer was used. The rotation that was followed was corn, oats, wheat, followed by seeding to grass. The sample consisted of the light brown, gravelly, sandy loam taken to a depth of eight inches.

No. 1895.— A brown, silty loam, ten inches deep, resting on a heavy yellow or mottled gray and yellow silt loam, having a depth of two feet; this, in turn, resting on shale and sandstone rock. Soil and sub-soil contain very large amounts of shale, and sandstone fragments. This soil occupies the highest hills and rolling plateaus of the

southern tier from Broom county to Chautauqua county. Crops grown are oats, grass, buckwheat, potatoes, rye, and small amounts of corn and wheat. Good apple orchards are found on this soil. The sample of soil was taken from the farm of Mr. J. J. Preswick, about three miles southeast of Ithaca, N. Y. The field was a potato field that gave a yield of about 150 bushels per acre with no application of a fertilizer of any kind. The previous yields were potatoes 100 to 150 bushels; oats, 30 bushels; grass, a scant ton per acre; and buckwheat, 12 to 15 bushels. This field had been cleared eighty years and no fertilizer, either stable manure or commercial, had ever been used.

No. 1896.— A brown or black loam, six to ten inches deep, resting on a heavy yellow, silty loam containing numerous shale fragments and having a depth of three feet or more, this, in turn, underlain by shale rock. This soil occurs typically developed on rolling uplands, but extends to lower levels along streams and lakes. It is derived from glacial material. It is found in Ashtabula county, Ohio, Chautauqua, Tompkins, and Cayuga counties, New York, and intermediate localities at from 12 to 2,000 feet above sea level. In New York, it is the basis of the dairying and general farming industries. The sample was collected on the farm of Charles Norris, about three miles northeast of Ithaca. The field was corn stubble and was manured the previous year with twenty-five loads of stable manure. No commercial fertilizer had been used on the field in twenty years. The rotation was corn, oats, and grass. The yields of corn were from 100 to 125 bushels of ears per acre; oats, 40 bushels; grass, 1½ to 2 tons per acre. The field had been cleared at least seventy-five years. The sample consisted of a brown loam, fairly well granulated, and contained a considerable amount of large flat shale and a high percentage of small flat shale chips.

No. 1897.— The soil on the Station farm is a rather heavy clay loam and probably is quite similar to the soils classed as Dunkirk clay. The sample used was taken from the upper eight inches of a garden that had been used for a number of years for the production of small fruits, particularly strawberries.

No. 1898.— This soil was a yellow to brown clay loam, six to twelve inches deep, underlain by mottled joint clay to a depth of six feet or more, this, in turn, underlain by boulder clay or by rock, occasionally underlain by gravel. This is a glacial lake sediment deposited in quiet water and is associated with gravelly loams and sandy loams of similar origin. In some areas, this type of soil is badly drained. The crops produced on it are wheat, oats, and grass. Corn and buckwheat are raised to less advantage. It is a typical Concord grape soil under favorable climatic conditions and with good drainage. It occurs along Lake Erie in Ashtabula county, Ohio, and in Chautauqua county, N. Y. It is widely distributed in small areas in northern central New York and around the "Finger Lakes." The sample was taken from a corn field on the Cornell University farm about 300 yards south of the new filtration plant. On this type of soil, Professor Roberts secured his wheat yields of forty bushels per acre and over, the hay yields being from three to four per tons acre in 1904.

No. 1900.— The sample of soil used was taken from the farm of J. V. Salisbury & Son, near Phelps, N. Y. This farm falls within the Onondaga limestone region.

No. 1901.— The soil used from this region was taken on the farm of F. A. Sirrine, near Riverhead, N. Y. It should be classed as a sandy loam, although it is not possible to state from existing information what class of sandy loams it falls into according to the classification of the Bureau of Soils.

No. 1902.— The town of Walton is situated in Delaware county, a region that is classified as to its geological characteristics as Catskill sandstone. The sample used was taken from the farm of Nathan Jenkins which is located in Walton.

Farm manure.— This manure was made from a herd of dairy cows that received a fairly rich grain ration combined with silage and hay, partly alfalfa.

Soil treatment.— The soil was contained in boxes fifteen inches square, inside measure, and six inches deep, holding about forty pounds of material. Distilled water was applied as needed during the growth of the plants. The crop grown was barley which was permitted to mature, the format on of seeds being satisfactory. One hundred and eighty boxes were used in the experiment, twenty being devoted to each of the nine soils. Each twenty boxes were divided into four duplicate groups. One set of duplicates (two boxes) received no fertilizer, another set (six boxes) muck the first year and leaf mold the second, another (six boxes) stable manure, and another (six boxes) chemicals. The treatment of these several groups for both years is disclosed in Tables I, II, III, and IV, Table IV giving the calculated amounts of fertilizing ingredients applied per acre.

TABLE I.— COMPOSITION OF SUBSTANCES APPLIED TO THE BOXES.

FERTILIZING INGREDIENTS.	ORGANIC MATTER.		NITROGEN.		AVAILABLE P_2O_5.		K_2O.	
	1st year.	2d year.	1st year.	2d year.	1st year.	2d year.	1st year.	2d year.
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Muck or leaf mold..	57.9	60.8	......	......	......	......	......	....
Manure...........	75.9	53.3	1.95	2.4	1.76	2.8	2.77	2.0
KNO_3...........	......	......	13.90	13.9	......	......	46.50	46.5
$NaNO_3$...........	......	......	16.40	16.4	......	......	......	....
Acid phosphate....	......	......	......	......	25.2	59.4	......	....

TABLE II.— QUANTITIES OF CHEMICALS AND OTHER MATERIALS APPLIED TO THE BOXES.

GROUP.	MUCK OR LEAF MOLD.		STABLE MANURE.		SODIUM NITRATE.		POTASSIUM NITRATE.		ACID PHOSPHATE.	
	*1st year.	†2d year.	1st year.	2d year.	1st year.	2d year.	1st year.	2d year.	1st year.	2d year.
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
1 (2 boxes)	.....	.....	.....	.....	.....	.....	.....	.....	.....	......
2 (6 boxes)	345 230 115	184.0 122.6 61.3	....	....	....	....	....	....	....	....
3 (6 boxes)	....	....	263.5 175.7 87.8	210 140 70	....	....	....	....	....	....
4 (6 boxes)	....	....	....	....	18.55 12.37 6.18	22.72 15.15 7.57	15.68 10.46 5.23	8.94 5.96 2.98	18.41 12.28 6.14	9.80 6.53 3.27

* Muck. † Leaf mold.

TABLE III.— QUANTITIES OF N, P_2O_5, AND K_2O APPLIED PER BOX.

Group.	Organic matter.		Nitrogen.		P_2O_5.		K_2O.	
	1st year.	2d year.	1st year.	2d year.	1st year.	2d year.	1st year.	2d year.
	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams
1 (2 boxes)........	......	......	......	......	......	......	......	....
2 (6 boxes)........	200.0 133.3 66.6	112.0 74.6 37.3	....	....	....	....	....	....
3 (6 boxes)........	200.0 133.3 66.6	112.0 74.6 37.3	5.22 3.48 1.74	5.00 3.33 1.66	4.64 3.09 1.55	5.82 3.88 1.94	7.30 4.87 2.43	4.16 2.77 1.39
4 (6 boxes)........	....	....	5.22 3.48 1.74	5.00 3.33 1.66	4.64 3.09 1.55	5.82 3.88 1.94	7.30 4.87 2.43	4.16 2.77 1.39

TABLE IV.— RATE OF APPLICATION PER ACRE.

Group.	Organic matter.		Nitrogen.		P_2O_5.		K_2O.	
	1st year.	2d year.	1st year.	2d year.	1st year.	2d year.	1st year.	2d year.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1 (Check)............	....	....	.....	.....	.....	.....	.....	......
2 (Muck or leaf mold)..	8,536.0 5,690.6 2,845.3	4,780.2 3,186.8 1,593.4	....	....	....	....	....	....
3 (Farm manure)......	8,536.0 5,690.6 2,845.3	4,780.2 3,186.8 1,593.4	222.8 148.5 74.3	213.4 142.3 71.1	198.0 132.0 66.0	248.4 165.6 82.8	311.6 207.7 103.8	117.5 118.4 59.2
4 (Chemicals).........	....	....	222.8 148.5 74.3	213.4 142.3 71.1	198.0 132.0 66.0	248.4 165.6 82.8	311.6 207.7 103.8	117.5 118.4 59.2

Results.— The first year the barley was planted in the boxes on January 10 and the crop was harvested as it matured at various dates from May 26 to June 22. The second year the planting occurred on December 18 and the crop was harvested during the latter part of May. The results secured with the various treatments, as measured by the amount of dry substance produced, are shown in Tables V, VI, and VII.

It is to be noted that in the first year's experiment the growth of crops where farm manure was applied was less even than where no application of fertilizer was made. There was no evident explanation of this result, but as a means of securing information during the second year special boxes of fresh soil were treated with farm manure alone

TABLE V.— YIELD OF BARLEY DRY SUBSTANCE — FIRST YEAR.

Average of two boxes.

TREATMENT.	SOILS.									AVERAGE.
	1894	1895	1896	1897	1898	1899	1900	1901	1902	
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
Untreated	39.8	51.2	30.6	44.4	90.3	17.9	11.2	11.6	4.9	33.5
Muck 345.10 grams	59.4	51.5	46.1	56.9	92.2	29.2	14.3	20.3	19.1	43.2
Muck 230.06 grams	54.2	57.9	42.3	52.0	94.0	24.8	14.0	18.6	15.2	41.4
Muck 115.00 grams	53.4	57.5	34.8	48.6	93.5	20.8	11.8	12.7	9.9	38.1
Manure 263.50 grams	23.5	26.0	26.3	15.8	74.0	14.2	8.6	11.8	6.5	22.9
Manure 175.66 grams	25.5	28.3	19.2	18.2	86.8	11.3	8.4	11.4	5.6	23.9
Manure 87.83 grams	33.2	37.4	26.3	27.4	94.2	10.3	13.4	10.1	5.5	28.6
Chemicals 52.64 grams	301.7	311.0	280.0	294.0	362.0	273.0	278.5	219.0	77.5	266.3
Chemicals 35.11 grams	240.5	246.0	234.0	265.0	292.5	217.0	250.0	178.5	63.8	220.8
Chemicals 17.55 grams	167.5	180.0	157.0	192.0	231.0	154.0	176.5	114.5	41.4	157.1

TABLE VI.— YIELD OF BARLEY DRY SUBSTANCE — SECOND YEAR.

Average of two boxes.

TREATMENT.	SOILS.									AVERAGE.
	1894	1895	1896	1897	1898	1899	1900	1901	1902	
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
Untreated	77.4	52.6	55.4	66.0	71.2	78.9	37.4	......	4.5	52.1
Leaf mold 184.0 grams	95.6	67.3	81.0	89.9	102.5	97.8	64.4	36.3	54.0	76.5
Leaf mold 122.6 grams	90.8	62.1	76.1	85.4	93.0	92.3	65.1	30.6	51.2	71.8
Leaf mold 61.3 grams	80.4	55.6	62.1	75.4	84.9	88.8	38.0	23.4	37.8	60.7
Manure 210 grams	186.6	180.2	181.9	130.3	182.5	190.1	120.7	66.8	152.5	154.6
Manure 140 grams	165.9	150.6	146.8	126.3	145.5	157.1	110.5	26.1	135.4	129.3
Manure 70 grams	134.5	125.1	138.1	114.5	125.8	131.4	90.3	40.9	106.7	111.9
Chemicals 41.46 grams	245.5	246.8	247.5	214.5	292.2	242.3	285.8	170.3	191.7	237.4
Chemicals 27.64 grams	228.0	208.7	217.5	237.8	251.3	221.6	258.3	159.3	155.4	215.3
Chemicals 13.82 grams	185.0	157.9	163.0	185.4	182.1	171.0	191.6	149.0	122.6	167.5

TABLE VII.— AVERAGE PRODUCTION OF BARLEY DRY SUBSTANCE FOR TWO YEARS ON NINE SOILS.

TREATMENT.	YIELDS.		
	1st year.	2d year.	Average, 2 years.
	Grams	*Grams*	*Grams*
No fertilizer	33.5	52.1	42.7
Muck or leaf mold, 3/3 quantity	43.2	76.5	59.8
Muck or leaf mold, 2/3 quantity	41.4	71.8	56.6
Muck or leaf mold, 1/3 quantity	38.1	60.7	49.4
Stable manure, 3/3 quantity	22.9	154.6	*154.6
Stable manure, 2/3 quantity	23.9	129.3	*129.3
Stable manure, 1/3 quantity	28.6	111.9	*111.9
Chemicals, 3/3 quantity	266.3	237.4	251.9
Chemicals, 2/3 quantity	220.8	215.3	218.0
Chemicals, 1/3 quantity	157.1	167.5	162.2

* For second year only.

and farm manure to which was added 40 grams of calcium oxide to each box, or at the rate of 2458 pounds per acre. Table VIII gives the average relative production of two boxes of each soil when treated with manure alone and with manure and lime.

TABLE VIII.— PRODUCTION OF BARLEY DRY SUBSTANCE WITH STABLE MANURE, WITH AND WITHOUT LIME.

SOIL.	MANURE 3/3 QUANTITY.		MANURE 2/3 QUANTITY.		MANURE 1/3 QUANTITY.	
	With lime.	Without lime.	With lime.	Without lime.	With lime.	Without lime.
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
1894	163.6	156.0	152.7	191.1	150.6	146.3
1895	174.3	154.7	149.5	179.1	153.6	102.1
1896	175.7	139.3	156.1	134.9	158.7	107.7
1897	149.5	119.1	137.3	106.4	128.7	94.6
1898	196.2	170.3	187.7	173.5	181.1	164.2
1899	127.4	89.7	112.4	85.1	118.8	73.5
1900	125.1	180.5	117.6	164.8	135.0	138.8
1901	66.1	90.6	65.6	89.3	72.1	29.8
1902	116.1	69.8	109.7	89.6	104.1	64.5
AVERAGE OF ALL BOXES	143.7	129.9	132.0	134.8	133.8	102.3

METHODS AND RESULTS WITH TWO SOILS

In the experiments previously described, with the statement of the results secured, fertilizers of a uniform composition have been applied in different quantities, as for instance, a given fertilizer mixture was applied in proportions of one, two, and three. In the succeeding season, experiments were carried on with two soils to which were added fertilizers differently compounded and applied in varying quantities

The soils.— The soils used included one from the Station Farm, known as Station soil, and a soil from the region known as Pine Plains, this being sandy in character and generally regarded as very inferior for the production of general farm crops. This latter fact is indicated not only by the crops produced in that particular locality but also by the natural vegetation.

Soil treatment.— This experiment involves forty-eight boxes of soil which were divided into the following groups:

Group 1. Boxes receiving no fertilizer.

Group 2. Boxes receiving nitrogen alone in proportions of one, two, and three.

Group 3. Boxes receiving phosphoric acid alone in proportions of one, two, and three.

Group 4. Boxes receiving potash alone in proportions of one, two, and three.

Group 5. Boxes receiving nitrogen in proportions of one, two, and three, each box receiving besides the largest amount of phosphoric acid.

Group 6. Boxes receiving nitrogen in proportions of one, two, and three, each box receiving besides the largest amount of potash.

Group 7. Boxes receiving nitrogen in proportions of one, two, and three, each box receiving besides the largest amount of both phosphoric acid and potash.

The boxes were planted to barley which was allowed to develop to maturity.

Results.— The kind and quantity of N, P_2O_5, and K_2O applied, and the production of dry substance under each method of treatment for both soils are given in the following table. The figures for the dry substance of straw and grain for each soil are the average of duplicate boxes.

TABLE IX.— YIELD OF BARLEY DRY SUBSTANCE WITH DIFFERENT FERTILIZER TREATMENTS ON TWO TYPES OF SOIL.

TREATMENT.	QUANTITY OF FERTILIZER APPLIED.			YIELD.					
				STATION SOIL.			PINE PLAINS SOIL.		
	N	P_2O_5	K_2O	Straw dry matter.	Grain dry matter.	Total dry matter.	Straw dry matter.	Grain dry matter.	Total dry matter.
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
Group No. 1. No fertilizer......	.....	.....	.....	15.6	11.3	26.9	31.3	24.3	55.6
Group No. 2. Nitrogen alone.									
1/3 N.........	1.254	.....	.....	52.3	36.1	88.4	61.1	57.1	118.2
2/3 N.........	2.508	.....	.....	63.5	41.7	105.2	84.0	66.2	150.2
3/3 N.........	3.762	.....	.....	75.0	54.6	129.6	97.0	56.9	153.9
Group No. 3. Phos. acid alone.									
1/3 P_2O_5......	.....	1.939	.....	14.8	12.9	27.7	29.4	26.7	56.1
2/3 P_2O_5......	.....	3.878	.....	13.5	12.2	25.7	35.9	25.4	61.3
3/3 P_2O_5......	.....	5.817	.....	17.3	16.7	34.0	33.7	28.7	62.4
Group No. 4. Potash alone.									
1/3 K_2O.......	.....	.....	1.386	12.0	10.0	22.0	27.6	22.8	50.4
2/3 K_2O.......	.....	.....	2.772	14.6	11.8	26.4	29.5	23.0	52.5
3/3 K_2O.......	.....	.....	4.158	12.7	14.3	27.0	29.6	24.9	54.5
Group No. 5. N & P_2O_5(3/3).									
1/3 N.........	1.254	5.817	.....	58.8	48.3	107.1	72.0	57.2	129.2
2/3 N.........	2.508	5.817	.....	90.5	72.1	162.6	91.8	76.9	168.7
3/3 N.........	3.762	5.817	.....	108.6	82.1	190.7	109.9	86.0	195.9
Group No. 6. N & K_2O(3/3).									
1/3 N.........	1.254	.....	4.158	57.6	46.4	104.0	74.8	53.3	128.1
2/3 N.........	2.508	.....	4.158	79.4	56.6	136.0	90.9	65.6	156.5
3/3 N.........	3.762	.....	4.158	74.5	42.9	117.4	94.8	62.1	156.9
Group No. 7. N, P_2O_5(3/3), K_2O (3/3).									
1/3 N.........	1.254	5.817	4.158	63.3	53.1	116.4	76.8	58.8	135.8
2/3 N.........	2.508	5.817	4.158	92.0	66.6	158.6	97.7	79.7	177.4
3/3 N.........	3.762	5.817	4.158	104.7	72.4	177.1	110.7	78.2	188.9

GENERAL DISCUSSION

The foregoing data show that the growth of the barley plant under forcing house conditions was very satisfactory. In the series of experiments where the various fertilizers were applied in unlike quantities the production of barley dry substance varied from the rate of one and one-fourth tons per acre to nearly seven and three-fourths tons. In the experiments where various combinations of fertilizing ingredients were used the growth was not as generous but was, nevertheless, very satisfactory.

The study of the data secured justifies the following comments:

1. The growth of barley was influenced very little by the application alone, of either muck or leaf-mold.

2. The failure of well composted farm manure to produce additional growth during the first year's experiments was not understood. No such effect was observed the second year, growth of the barley plant in these boxes being very satisfactory.

3. With a single exception the growth of the barley plant increased with the increase of the amount of fertilizer applied tho not proportionately, the increase from the proportion of one to two being larger than that due to further increase.

4. The boxes to which commercial fertilizers were applied gave a much larger production of barley dry substance than those receiving stable manure, the quantities of nitrogen, phosphoric acid, and potash being the same in the two cases.

5. Lime (CaH_2O_2) applied in connection with farm manure had a very irregular effect on the growth of the barley plant in the nine soils. With four soils the increased growth was large, with three there was a manifest advantage from the use of the lime, and with two there was an apparent injury.

6. In the experiments with the two soils where fertilizers were applied in different combinations, nitrogen in the form of nitrate of soda exerted the dominant influence, the increasing crop where this was applied alone being very marked.

7. The application of phosphoric acid alone and of potash alone in neither case resulted in any special addition of crop.

8. The combination of nitrogen and phosphoric acid caused a somewhat larger growth of barley than nitrogen alone altho the increase from the addition of the phosphoric acid to the nitrogen was somewhat insignificant, as compared to the increase due to the application of nitrogen alone.

9. The combination of nitrogen and potash gave practically the same production of dry substance as nitrogen alone.

10. The combination of nitrogen with both phosphoric acid and potash gave practically the same yield of dry substance as the combination of nitrogen and phosphoric acid. Either alone or in combination, potash appeared to exert little influence on the growth of the barley plants.

It is a well observed fact that vegetation experiments with soils in the forcing house give results quite unlike those that would be reached with the same soils under field conditions. For instance, the Pine Plains soil which is properly regarded as of an inferior type for general cropping, produced twice as much dry substance on the boxes where no fertilizer was applied as did the Station soil, the latter soil being notably fertile in field culture. The application of the fertilizers caused as large production on the Pine Plains soils as on the Station soil. Moreover, the application of nitrogen alone gave a very marked increase of crop on both soils and it is doubtful if a similar result could be secured by ordinary field culture. The explanation of these facts is difficult.

Forcing house conditions vary from field conditions in three ways, namely:

1. The soil in the experimental boxes was more thoroly pulverized than occurs in field culture.

2. The temperature of the forcing house was maintained at a favorable and nearly constant point, whereas, in field culture the soil and plants are subjected to great variations of temperature.

3. Water was applied to the boxes in the forcing house in the amount regarded as most favorable for plant growth, whereas, in the field variations of moisture occur, ranging from a surplus to a deficiency.

Just how these unlike conditions would affect the availability of the plant food in the soil and the general welfare of the plant is not well understood. It may be suggested, however, that the constant warmth and abundant moisture to which the forcing house soil was subjected would be favorable, thru the process of solution, to the maximum use of soil ingredients. Besides, these uniformly favorable conditions to which the plants were subjected, in the matter of moisture and temperature and the absence from insect and fungus depredations, enabled the plant to exert its maximum vigor in securing the materials for growth. Whatever may be the explanation, this is obvious, that in so far as forcing house conditions may be duplicated in the field, just so far is the farmer promoting luxuriant plant growth. The unlike results in growing plants under the two conditions present an interesting problem. In any case, the data here recorded are suggestive as to the use of fertilizers for forcing crops under glass.

RELATION OF FERTILIZERS AND PLANT GROWTH TO SOIL SOLUTIONS

There has been carried on in connection with the experiments previously described studies on the influence of fertilizers and plant growth upon soil solutions. Much of the data secured is in accord with existing knowledge which needs no confirmation, while certain of the results reached afford testimony that is worthy, perhaps, of more than passing notice.

Past investigations have clearly shown what occurs quite promptly when nitrates and soluble compounds of phosphorus and potassium are mixed with soil. The nitrogen remains in a soluble compound, apparently as calcium nitrate, the phosphorus almost wholly enters into water insoluble forms, while such changes occur with the potassium as render its partial removal from its new combinations possible only through continued leaching. A study of drainage waters corroborates these general conclusions.

It seemed desirable, because of the favorable opportunity offered, to secure additional data as to the persistence of the states of solubility above noted. It was believed to be especially desirable to secure observations on the influence of plant growth on soil solutions.

PLAN OF STUDY

This study was carried on in part with the nine soils on which two crops of barley were grown as shown in Tables I to VII. It should be noted that the second crop was grown in the same boxes as the first one without removing the soil. Fertilizers carrying nitrogen, phosphorus, and potassium in the soluble forms were added to the soil as shown in Tables I to III, and the crops produced are shown in Tables V and VI. Following the harvesting of the second crop of barley, samples were selected from each box and the amounts of nitrogen, phosphorus, and potassium brought into solution were determined.

In order to secure data on the persistence of soluble compounds in the soil following the application of soluble fertilizers and, also, to obtain data on the proportion of soluble material in the soil on which no crops had been grown as compared with the soil on which the two crops of barley were grown, fertilizers were applied to a

certain number of the boxes in the quantities shown in Table X, one box receiving no fertilizer. As indicated, no crop was grown on these boxes.

TABLE X.— AMOUNT OF FERTILIZING INGREDIENTS APPLIED TO UNCROPPED BOXES.

RATION.	SODIUM NITRATE.	POTASSIUM NITRATE.	TOTAL NITROGEN.	ACID PHOSPHATE.	P_2O_5	K_2O
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
One-third quantity....	6.18	5.23	1.74	6.14	1.55	2.43
Two-thirds quantity..	12.36	10.46	3.48	12.28	3.09	4.86
Full quantity........	18.55	15.69	5.22	18.41	4.64	7.29

Samples were selected from these boxes on seven different dates, the first being January 3 and the last June 15, and the water soluble material determined.

DETERMINATION OF WATER SOLUBLES IN NINE SOILS

Five hundred grams of air dried soil were placed in a two quart container, to which one thousand cc. of distilled water was added. After shaking for three minutes, the mixture was allowed to stand for twenty minutes to allow the coarse particles to settle, after which the supernatant liquid was filtered through a Chamberlain filter under pressure. The quantities of nitrogen, phosphorus, and potassium held in solution were determined by approved methods. By this plan it became possible to compare soil solutious from the nine soils on which no crops had been grown with the soils producing two crops of barley, the fertilizer treatment being essentially the same. These comparisons are shown in Table XI.

TABLE XI.—INFLUENCE OF FERTILIZERS AND CROPPING ON WATER SOLUBLE SUBSTANCES IN NINE DIFFERENT SOILS.

Soil.	Parts in solution per million of soil.					Yield water free sub-stance in grams.
	Total sol. sub.	Inorg. sol. sub.	K_2O	P_2O_5	NO_3	
Results when no fertilizer was applied.						
1894, Before cropping....	330	143	15.00	2.20	135.0	83.0
After cropping......	84	54	3.50	3.00	3.4	
Loss from cropping..	246	89	11.50	—.80	131.6	
1895, Before cropping.....	331	133	9.00	2.50	140.0	56.5
After cropping......	72	43	1.00	3.10	2.2	
Loss from cropping..	259	90	8.00	—.60	137.8	
1896, Before cropping.....	284	102	9.00	1.71	122.0	59.7
After cropping......	55	40	3.20	2.10	1.4	
Loss from cropping..	229	62	5.80	—.39	120.6	
1897, Before cropping.....	308	136	22.00	3.70	102.0	71.5
After cropping......	226	148	13.80	2.30	2.7	
Loss from cropping..	82	—12	8.20	1.40	99.3	
1898, Before cropping.....	454	178	22.00	2.40	171.0	76.5
After cropping......	124	71	1.10	3.60	2.6	
Loss from cropping..	330	107	20.90	—1.20	168.4	
1899, Before cropping.....	180	72	11.00	2.00	68.0	84.0
After cropping......	34	16	.26	3.20	.6	
Loss from cropping..	146	56	10.70	—1.20	67.4	
1900, Before cropping.....	1,709	1,365	16.00	3.20	72.0	40.2
After cropping......	650	540	4.70	2.30	1.0	
Loss from cropping..	1,059	825	11.30	.90	71.0	
1901, Before cropping.....	125	78	10.00	3.50	24.0	36.3
After cropping......	82	52	1.80	2.80	1.4	
Loss from cropping..	43	26	8.20	.70	22.6	
1902, Before cropping.....	179	57	7.40	2.70	83.0	00.0
After cropping......	195	59	4.20	3.50	61.0	
Loss from cropping..	—16	—2	3.20	—.80	22.0	

TABLE XI.— (*continued*).

SOIL.	PARTS IN SOLUTION PER MILLION OF SOIL.					YIELD WATER FREE SUBSTANCE IN GRAMS.
	Total sol. sub.	Inorg. sol. sub.	K_2O	P_2O_5	NO_3	
RESULTS WHEN 1/3 FERTILIZER RATION WAS APPLIED.						
1894, Before cropping.....	777	475	48.0	2.8	364.0	185.0
After cropping......	115	53	1.9	3.2	1.7	
Loss from cropping..	662	422	46.1	—.4	362.3	
1895, Before cropping.....	745	434	39.0	2.4	338.0	159.9
After cropping......	182	136	2.8	3.5	1.1	
Loss from cropping..	563	298	36.2	—1.1	336.9	
1896, Before cropping.....	841	478	52.0	1.6	393.0	163.0
After cropping......	146	82	7.6	3.3	1.4	
Loss from cropping..	695	396	44.4	—1.7	391.6	
1897, Before cropping.....	700	424	59.0	6.2	264.0	185.7
After cropping......	328	209	4.5	6.8	4.7	
Loss from cropping..	372	215	54.5	— .6	259.3	
1898, Before cropping.....	920	498	53.0	2.6	403.0	182.1
After cropping......	248	160	4.6	3.8	2.6	
Loss from cropping..	672	338	48.4	—1.2	400.4	
1899, Before cropping.....	529	289	33.0	2.1	200.0	171.0
After cropping......	99	42	6.0	2.3	1.3	
Loss from cropping..	439	247	27.0	—.2	198.7	
1900, Before cropping.....	2237	1799	40.0	1.6	198.0	191.6
After cropping......	416	334	8.6	2.4	1.5	
Loss from cropping..	1821	1465	31.4	—.8	196.5	
1901, Before cropping.....	579	437	78.0	3.1	234.0	149.0
After cropping......	66	43	2.5	3.8	1.8	
Loss from cropping..	513	394	75.5	—.7	232.2	
1902, Before cropping.....	608	347	33.0	2.2	292.0	122.6
After cropping......	92	56	7.4	3.1	.9	
Loss from cropping..	516	291	25.6	—.9	291.1	

TABLE XI.—(*continued*).

Soil.	Parts in solution per million of soil.					Yield water free substance in grams.
	Total sol. sub.	Inorg. sol. sub.	K_2O	P_2O_5	NO_3	
Results when 2/3 fertilizer ration was applied.						
1894, Before cropping	991	677	86.0	2.9	411.0	228.0
After cropping	128	52	7.8	6.5	3.5	
Loss from cropping	863	625	78.2	—3.6	407.5	
1895, Before cropping	937	624	73.0	2.6	392.0	208.7
After cropping	195	114	2.1	4.3	2.2	
Loss from cropping	742	510	70.9	—1.7	389.8	
1896, Before cropping	958	648	85.0	2.3	418.0	217.5
After cropping	301	146	12.2	3.2	3.0	
Loss from cropping	657	502	72.8	—.9	415.0	
1897, Before cropping	1,052	718	87.0	11.6	450.0	237.8
After cropping	211	124	5.8	17.6	1.8	
Loss from cropping	841	594	81.2	—6.0	448.2	
1898, Before cropping	1,205	744	86.0	5.2	524.0	251.3
After cropping	449	258	3.2	8.0	2.2	
Loss from cropping	756	486	82.8	—2.8	521.8	
1899, Before cropping	673	477	57.0	2.6	307.0	221.6
After cropping	128	60	6.6	5.7	1.3	
Loss from cropping	545	417	50.4	—3.1	305.7	
1900, Before cropping	2,063	1,616	60.0	2.3	379.0	258.3
After cropping	484	315	5.4	3.1	3.0	
Loss from cropping	1,579	1,301	54.6	—.8	376.0	
1901, Before cropping	799	640	134.0	7.5	275.0	159.3
After cropping	47	28	2.3	8.2	1.5	
Loss from cropping	752	612	131.7	—.7	273.5	
1902, Before cropping	993	682	66.0	1.9	490.0	155.4
After cropping	234	134	5.6	4.3	16.6	
Loss from cropping	759	548	60.4	—2.4	473.4	

TABLE XI.— (*concluded*).

SOIL.	PARTS IN SOLUTION PER MILLION OF SOIL.					YIELD WATER FREE SUBSTANCE IN GRAMS.
	Total sol. sub.	Inorg. sol. sub.	K_2O	P_2O_5	NO_3	
RESULTS WHEN 3/3 FERTILIZER RATION WAS APPLIED.						
1894, Before cropping.....	1,546	1,161	138.0	3.0	677.0	245.5
After cropping......	320	151	11.8	9.6	7.5	
Loss from cropping..	1,226	1,010	126.2	—6.6	669.5	
1895, Before cropping.....	1,742	1,262	138.0	3.0	802.0	246.8
After cropping......	397	240	4.3	9.6	4.3	
Loss from cropping..	1,345	1,022	133.7	—6.6	797.7	
1896, Before cropping.....	1,326	939	128.0	3.0	595.0	247.5
After cropping......	292	144	3.0	6.2	9.4	
Loss from cropping..	1,034	795	125.0	—3.2	585.6	
1897, Before cropping.....	1,462	1,051	131.0	16.2	563.0	214.5
After cropping......	292	168	4.5	30.0	2.1	
Loss from cropping..	1,170	883	126.5	—13.8	560.9	
1898, Before cropping.....	1,652	1,137	128.0	15.2	748.0	292.2
After cropping......	436	242	2.8	14.0	2.8	
Loss from cropping..	1,216	895	125.2	1.2	745.2	
1899, Before cropping.....	1,451	1,063	116.0	3.9	611.0	242.3
After cropping.....	264	118	2.3	9.6	11.7	
Loss from cropping..	1,187	945	113.7	—5.7	599.3	
1900, Before cropping.....	2,902	2,252	103.0	3.8	610.0	285.8
After cropping......	530	178	10.1	11.5	1.7	
Loss from cropping..	2,372	2,074	92.9	—7.7	608.3	
1901, Before cropping.....	1,448	1,222	219.0	12.1	622.0	170.3
After cropping......	118	64	5.3	17.5	3.8	
Loss from cropping..	1,330	1,158	213.7	—5.4	618.2	
1902, Before cropping.....	1,290	860	107.0	2.7	591.0	191.7
After cropping......	476	268	6.6	3.1	134.0	
Loss from cropping..	814	592	100.4	—.4	457.0	

DETERMINATION OF WATER SOLUBLES IN ONE SOIL

A study of the effect of soluble fertilizers and plant growth upon soil solutions has also been carried thru with a single soil under a plan calculated to give fuller and more carefully graded data than were secured from the nine soils as previously set forth.

In this study 36 boxes were used, each containing 33 pounds of air-dried soil from the Station farm. Thirty-two of these boxes were divided into four sets of eight boxes in a set. Each set of eight was fertilized as follows:

TABLE XII.—FERTILIZERS APPLIED TO THE BOXES.

Sets.	Sodium nitrate.		Potassium nitrate.		K_2O	Acid phosphate.	
	$NaNO_3$	N	KNO_3	N		Acid phos.	P_2O_5
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
1, 8 boxes, no chemicals	......	......	......	......	......	......	......
2, 8 boxes, 1/3 chemicals	3.787	.627	2.979	.412	1.386	3.266	1.939
3, 8 boxes, 2/3 chemicals	7.574	1.255	5.958	.824	2.772	6.532	3.878
4, 8 boxes, 3/3 chemicals	11.361	1.881	8.936	1.238	4.158	9.797	5.817

The chemicals used were Kahlbaum's chemically pure. The potassium nitrate was added before seeding and the sodium nitrate later, February 23. All the boxes were seeded alike to barley on January 24. One set of four boxes was not seeded but was kept free of weeds and under moisture conditions similar to those maintained in the boxes in which barley was growing. Of the remaining sets of four boxes which were seeded, one set received no chemicals and the other three were used for the three quantities of chemicals as shown in Table XII and indicated by 1/3, 2/3, and 3/3.

Barley was harvested from two boxes of each set at four different periods, namely, March 18, April 15, May 10, and June 1. At the times of harvesting, samples of soil were taken from the boxes from which the crop was removed and also from the boxes not seeded. These samples were submitted to leaching, according to the method described on page 41. The yields of dry substance from the boxes treated in the several ways are shown in the following table.

TABLE XIII.— YIELD OF BARLEY DRY SUBSTANCE FROM VARIOUSLY TREATED BOXES.

Averages of two boxes.

MANNER OF TREATMENT.	CROP OF MARCH 18.	CROP OF APRIL 15.	CROP OF MAY 10.	CROP OF JUNE 1.
	Grams	*Grams*	*Grams*	*Grams*
No chemicals	14.4	57.1	84.8	101.7
1/3 chemicals	17.5	68.4	114.0	177.7
2/3 chemicals	18.8	66.1	126.2	214.4
3/3 chemicals	15.5	73.7	137.9	222.2

Solutions from the unseeded boxes.— As previously stated, the soil in the boxes on which barley was not grown was sampled at four different periods and submitted to leaching according to the method previously described. The amounts of total and inorganic solids, as shown by the ignition of the total solids dissolved, potassium oxide, phosphoric acid, and nitrogen were determined in the water solution. It was expected by this method to show whether any changes in solubilities occurred during a considerable period of time.

EFFECT OF PLANT GROWTH ON SOIL SOLUBLES

Not only were the unseeded boxes sampled, but as stated the barley was harvested from the boxes at four different periods and the soil sampled from these boxes at the time of removing the crop. These soil samples were leached as described.

The following tables show the content of all the soil solutions at the time of the four periods of removing the crops.

TABLE XIV.— PARTIAL CONTENT OF SOIL SOLUTIONS AT FOUR PERIODS OF TIME, FROM SOIL SUSTAINING NO PLANT GROWTH, WITHOUT FERTILIZER, AND WITH CHEMICALS IN THREE DIFFERENT QUANTITIES.

Figures show parts per million of soil.

DATE OF SAMPLING.	TOTAL SOLIDS.	INORGANIC SOLIDS.	K_2O	P_2O_5	NO_3
		NO FERTILIZER.			
March 18	898	473	29.2	4.8	5.6
April 15	825	323	29.6	4.0	106.0
May 10	845	371	27.2	7.6	187.6
June 1	876	384	37.2	4.0	67.6
Average	861	388	30.8	5.1	91.7
		1/3 CHEMICALS.			
March 18	1,424	782	41.2	8.8	8.4
April 15	1,444	703	35.6	6.4	556.0
May 10	1,412	826	40.8	8.8	455.0
June 1	1,529	747	48.8	7.6	520.0
Average	1,452	764	41.6	7.9	385.8
		2/3 CHEMICALS.			
March 18	2,672	1,835	74.8	21.6	1,040.0
April 15	1,718	1,365	48.8	14.4	652.0
May 10	1,280	667	44.4	14.0	375.0
June 1	1,511	723	60.0	11.6	500.0
Average	1,795	1,147	57.0	15.4	642.0
		3/3 CHEMICALS.			
March 18	2,168	1,267	62.0	16.4	860.0
April 15	2,990	1,882	67.6	23.6	1,478.0
May 10	2,920	2,134	78.0	24.0	1,090.0
June 1	2,015	1,208	85.2	17.2	666.0
Average	2,523	1,623	73.2	20.3	1,023.0

TABLE XV.— PARTIAL CONTENTS OF WATER SOLUTIONS FROM SOILS SUSTAINING NO PLANT GROWTH AND SOILS IN WHICH BARLEY WAS GROWN WITHOUT APPLYING CHEMICALS AND WITH CHEMICALS IN THREE PROPORTIONS.

DATE OF SAMPLING.	TOTAL SOLIDS.*	INORGANIC SOLIDS.*	K_2O*	P_2O_5*	NO_3*	YIELD DRY SUBSTANCE IN GRAMS.
			NO FERTILIZER.			
Blank, average	861	388	30.8	5.1	91.7	....
March 18	436	208	13.2	9.8	2.6	15.4
April 15	427	185	8.2	4.8	2.0	57.1
May 10	441	163	8.0	2.8	1.8	84.8
June 1	445	172	9.6	6.8	4.6	102.7
Loss on June 1	416	216	21.2	—1.7	87.1	....
			1/3 CHEMICALS.			
Blank, average	1,452	764	41.6	7.9	385.0	....
March 18	679	328	18.2	12.2	39.6	17.5
April 15	493	222	8.4	7.9	4.6	68.4
May 10	639	214	10.4	5.6	2.0	114.0
June 1	521	189	10.0	8.6	6.2	177.7
Loss on June 1	931	575	31.6	—.7	378.8	....
			2/3 CHEMICALS.			
Blank, average	1,795	1,147	57.0	15.4	642.0	....
March 18	988	515	28.2	21.2	302.0	18.8
April 15	594	255	9.6	21.4	11.6	66.1
May 10	664	237	8.0	13.8	4.6	126.2
June 1	516	242	10.6	16.2	17.8	214.4
Loss on June 1	1,279	905	46.4	—.8	624.2	....
			3/3 CHEMICALS.			
Blank, average	2,523	1,623	73.2	20.3	1,023.0	....
March 18	1,578	814	53.4	27.8	23.2	15.5
April 15	747	351	10.6	38.0	55.4	73.7
May 10	728	313	8.8	26.0	6.2	137.9
June 1	720	277	10.8	27.6	7.4	222.2
Loss on June 1	1,803	1,346	62.4	—7.3	1,015.6	....

* Figures show parts per million of soil.

DISCUSSION OF RESULTS

The application to the various soils of soluble compounds of nitrogen, phosphorus, and potassium has materially increased the proportion of water solubles in the soils, this increase being least with phosphorus and largest with nitrogen. These results are in accordance with existing knowledge.

In general, these solubilities persisted without material change in the boxes in which the barley plant was not growing. The results were not entirely uniform, but justify the foregoing statement as to the persistence of compounds of these elements in a water soluble form. Conditions under which these observations were made were not similar to what might exist in the field, especially at the time of considerable water precipitation. The fertilizing materials were mixed with thirty pounds of soil, having a depth of about six inches. Probably in ordinary cultivation the incorporation of fertilizers in the soil does not reach this depth, but in case of rains there would be movements of water in the soil carrying the soluble compounds to lower levels which might very materially diminish the proportion of solubles, especially with the phosphorus and potassium. Without rain, the conditions might not be greatly unlike what existed under forcing house conditions.

The effect of the growth of crops upon water solubles is shown to be very marked. This appears to be true in the case of the nine different soils on which two crops were grown. The data found in Table XI not only give evidence of the large increase in solubles, due to the application of fertilizers, but also make very evident the great reduction in the water soluble compounds thru the growth of two crops of barley which were not harvested until maturity.

In the case of a single soil taken from the Station farm the boxes were seeded on January 24. On March 18, the immature barley was harvested on certain of the boxes. The amount of dry matter in the crop harvested at that time was found to vary from 15.4 to 18.8 grams per box. Notwithstanding this small growth, a very large proportion of the water soluble nitrogen and potassium had been utilized by the plants. On April 15, the growth of dry matter had increased to 57 grams per box where no chemicals were applied, and to 73.7 grams in the boxes receiving the full application of chemicals. A still further decrease in water solubles had taken place. On May 10,

with much increased production of dry matter, the water solubles had remained practically unchanged, which was also true when the full crop of mature plants was harvested on June first.

The striking facts in this connection are that the plants utilized the soluble material and that the reduction of this material in the soil was rapid even before the plants had attained considerable growth. In the later stages, the water solubles seemed to be maintained somewhat on a level, which was not greatly different, with the exception of the phosphorus, from the levels in boxes receiving no fertilizer. These observations agree with former conclusions that there is a proportion of water solubles maintained in the soil at nearly a constant level, irrespective of the growth of vegetation which the soil is sustaining.

It would seem that the data acquired from these studies have a significant bearing on the importance of the solubility of the essential ingredients of fertilizers, especially in the production of quickly growing crops. Plants accumulate a large proportion of the needed nitrogen and ash ingredients during the early stages of growth and in forcing house culture, in vegetable gardening, and for the growth of such crops as cabbages, potatoes, and wheat an adequate supply of immediately available food would seem to be a prerequisite for successful cropping.

A PROGRESS REPORT OF FERTILIZER EXPERIMENTS WITH FRUITS *

R. C. COLLISON

SUMMARY

Experiments on the fertilization of fruit trees, including the apple, pear, and cherry, and also similar experiments with grapes are here reported.

This is intended for a progress report covering the years 1912 to 1919, inclusive.

A general plan of fertilizer treatment, based on data showing the quantities of plant food removed by trees and on general practice, was adopted. This plan was different, however, for nursery stock and for grapes.

Records of growth increase and of yields of fruit were taken in all cases.

APPLE

Three apple orchards were under experiment and were located on soils more or less representative of the fruit soils of the State. Two were Baldwin orchards in their prime, the third a young Spy orchard not yet bearing. The two Baldwin orchards have given erratic results in yield and growth, which, together with data on growth from one of the orchards for five years previous to the experiment, force us to conclude that variations in results as between plats have been due to factors other than fertilizer treatment.

In the Spy orchard growth has been generally increased by fertilizers, but rather inconsistently as between different treatments.

No significant differences were noted in color and size of fruit.

CHERRY

The experiment reported was for one Montmorency orchard on Ontario loam soil.

In this orchard, fertilizers have increased yields, this being particularly true of nitrogen and, to a less extent, of phosphorus and potassium. If these increases are calculated to a cost basis,

* Reprint of Bulletin No. 477, June, 1920.

however, fertilization has been made at a loss financially. The growth of the trees has also been increased to some extent by fertilizers.

PEAR

One young Kieffer pear orchard was fertilized according to the general plan, but unfortunately, two years' fertilization were omitted from the seven year period, so that up to the present time too rigid conclusions cannot be drawn. The orchard is admirably situated for an experiment of this type, so that the next five years' results may be significant.

GRAPE

A young vineyard of Concord grapes of about four acres in extent in Chatauqua County was placed under systematic fertilizer treatment in 1913. The plan included previous drainage and soil treatment. General basal soil treatment was emphasized rather than the yearly application of fertilizer combinations. Up to the present time the indications are that available nitrogen may be a factor in the vineyard. One of the duplicate series of plats will be arranged in 1920 to give comparisons of nitrogen, phosphorus, and potassium. Manure will also be included.

APPLE NURSERY STOCK

Fertilizers were applied to newly budded nursery stock of three varieties, Baldwin, Oldenburg, and McIntosh. The Baldwins have, in the same period, made larger trees than either Oldenburg or McIntosh. Rock phosphate and manure and rock phosphate and potash have increased the growth of the McIntosh and Baldwin stock. Potash alone apparently increased the growth of McIntosh, but not of Baldwin. Nitrate of soda in no case seems to have increased growth.

These seven to eight years' results in the fertilization of different fruits have not strengthened the writer's opinion of the value of fertilizer experiments with tree fruits. It was thought that several of the soils used would respond to fertilizer treatment with trees. Possibly the next five years will give more positive results. From the data at hand, one must conclude that, in general, on our better fruit soils differences in growth and yields due to other causes have far outweighed those due to the fertilizer treatments.

INTRODUCTION

In the spring of 1896, an experiment was begun at this Station on fertilizing Rome Beauty apples. In 1911 the results of 15 years' work were published as Bulletin No. 339 from this Station.

It is necessary to quote only one paragraph from the summary of this bulletin to explain why the work on orchard fertilization has been extended and broadened into the experiments reported in the present publication. The paragraph is as follows: "The trees in this experiment would have been practically as well off had not an ounce of fertilizer been applied to them. One must conclude that if fertilizers have no value in this orchard, they have no value in many other orchards in New York."

To determine to what extent this conclusion was applicable to other orchards on different soils, a number of orchards were chosen, in the years 1912 and 1913, including apple, pear, peach, and cherry, carefully platted, and placed under fertilizer experiment.

The experiments were originally planned as cooperative ones between the Departments of Soils and Horticulture. The sites of these orchards were selected by U. P. Hedrick, Horticulturist, and J. F. Barker, former Agronomist. The general fertilizer treatment was planned by J. F. Barker; and the work was then placed under the care of the writer, who has remained in charge to the present time.

The writer here wishes to express his sense of obligation to both these men for their cooperation and for many valuable suggestions.

GENERAL PROBLEM

Comparatively little is definitely known concerning the food requirements of fruit trees. What data we have on the subject are the results of a few experiments which have been made under widely different conditions, together with a small amount of chemical data as to the composition of the tree and its products of growth.

It is obviously impossible to place the tree under controlled conditions as in the case of some smaller agricultural plants, because we are particularly interested in the tree during its bearing period. It can be safely stated that a tree requires the same plant food elements as do other crops, but what proportion and amount will be profitable in any given case is another question.

As pointed out by Hedrick (1911),[1] a number of very important differences between fruit trees and ordinary farm crops make the problem of the requirements of trees a difficult one.

If a fertilizer experiment on trees could be continued over a period of 100 years, the effects of the exhaustion of plant food might readily show themselves in even the most fertile soils and under the best cultural conditions, providing no plant food was returned to the soil. It is a general law of nature that no crop can be removed from a soil year after year without ultimate exhaustion of fertility and a final lowering of crop yields. At what particular time the manifestation of such a law makes itself felt in the case of the orchard depends on many factors such as the natural fertility, size, kind, and number of crops removed, fertility replaced either as fertilizer or in crop residues, loss from the soil in drainage, etc.

These factors may not vitally concern the present orchard-man but may concern his great grandchildren. In other words the subject bears some relation to the conservation problem.

About all that can be said with regard to any experiment, which has been carefully planned and carried out, is that such and such facts came to light under the conditions of that particular experiment, and that they might be more or less applicable elsewhere, providing conditions were similar.

WORK ALREADY DONE ON THE SUBJECT

While noting the work which has already been done in a systematic way on this important subject, it was thought best to first give some reasons for the supposed necessity of fertilization, also something of the functions of the fertilizer constituents in the physiology of growth and fruit production.

Of the many chemical elements present in the environment of the plant only ten seem to be essential to normal growth, namely, nitrogen, hydrogen, oxygen, carbon, phosphorus, potassium, sulfur, calcium, magnesium, and iron. In some plants chlorine, silicon, and sodium also seem necessary. Only three of the ten elements mentioned are usually important from the standpoint of fertilization, namely, nitrogen, phosphorus, and potassium; while, in many soils,

[1]Reference to Literature Cited, p. 100.

calcium should be included, and in a few sulfur also. We will here confine ourselves to the four, nitrogen, phosphorus, potassium, and calcium or lime.

IMPORTANCE OF NITROGEN

Of all the elements essential to plant growth, nitrogen is perhaps the most important. Nitrogen enters into the structure of the growing cell of the plant and is absolutely necessary for the production of leaf, wood, seed, and fruit. It is also found in cell sap.

Nitrogen fertilization tends to increase the luxuriance of the leaves, stems, and vegetative organs, while such plants are usually darker green. When nitrogen is excessive, there is a tendency for the plant to produce no reproductive organs and seeds.

Maze (1916) found that 0.5 gram in 1000 of ammonium salt and 2 grams per 1000 of nitrate injured many plants.

Remy (1913) found, with apples and dwarf pears, that nitrogen was necessary for abundant fruit-bud production. He also found that the nitrogen content of leaves varied with the amount of nitrogen applied. Where nitrogen was withheld the phosphorus content of the leaves was higher.

Alderman (1915), at the West Virginia Station, found that nitrogen on peaches gave the best results of all incomplete fertilizers. It increased vigor, foliage, and fruit. The fruit, however, developed less color. It has been noted in many cases that nitrogen has this effect on color. This may be due both to a direct action on the tissue changes, which results in pigment production, and to the production of denser foliage which protects the fruit from sunlight, a necessary factor in color change. Observations seem to indicate that it is largely the latter.

Whitten (1917) of the Missouri Station found that nitrogen produced greater vigor in peach trees, either when used alone or in combination. With apples, there was more blight on the nitrogen rows. Whitten and Wiggans (1917) of the same station also found that with peaches nitrogen fertilization resulted in better and larger trees; but that the fruit on these trees was smaller in size, altho greater in quantity. This was true of both nitrate of soda and dried blood. In some cases the number of peaches was increased 50 per cent but the individuals averaged only 60 per cent of the weight of those on the check trees. They also found that nitrogen increased the number of apples on trees just coming into bearing.

Woods (1918) reports that at the Maine Station an application of 1000 pounds per acre of a 5–8–7 fertilizer was made to Baldwin apple trees and, in addition, to some of the trees was added 100 pounds of nitrate of soda per acre. It was found that there was no increase in growth and yield due to the increased nitrogen.

The Ohio and Pennsylvania Stations report large increases in yield of apples from nitrogen fertilization.

At the New Jersey Station, Blake and Farley (1912) report a gain in size of fruit in apples due to nitrogen, with very little difference in time of ripening. As the trees advanced in age, the yield was increased by nitrogen.

At the Delaware Station, Neale (1891) reports an increased average growth of new wood in peaches due to the addition of nitrate of soda.

IMPORTANCE OF PHOSPHORUS

Phosphorus is an important constituent of many proteins and is essential to the development of the cell. It is present in large amount in seeds and is necessary to their development. Phosphorus constitutes a large part of the ash of seeds. The assimilation of this element is rapid, and takes place largely during the early stages of growth. The element must be presented to the plant in highly oxidized forms, such as salts of phosphoric acid. Phosphorus is a constituent in which many soils are low and with many soils it is probably the element most likely to be a limiting factor in ordinary farm crop production.

For practical purposes, data on the effect of phosphorus in tree growth and fruit production are very scarce.

Alderman (1915) of the West Virginia Station states that on a thin shale soil basic slag, which is a common phosphorus fertilizer, caused less vigorous foliage and higher color of fruit. Acid phosphate, at the rate of from 2 to 5 pounds per tree, produced no effect on fruit, foliage, or wood; while dissolved bone, 5 pounds per tree, produced a slight benefit.

Neale (1891) found that phosphorus alone gave considerable increase in new wood with a block of 144 peach trees. When combined with nitrogen there was still a good increase, but with potassium no increase was obtained.

The New York and New Hampshire Stations report no benefit from phosphorus on apples. The Pennsylvania Station reports no effect of phosphorus alone on yield or growth of apples, but a small effect when combined with nitrogen.

IMPORTANCE OF POTASSIUM

Potassium seems to be an essential element in the protoplasm of all cells. It is one of the least variable of the elements, being distributed fairly uniformly thruout the entire plant. Potassium occurs combined with organic acids in cell sap and so may be important in regulating the acidity of the sap. It seems to be important in maintaining cell turgidity. Plant tissues high in reserve carbohydrate seem to be high in potassium so that the element is thought to be essential to the fixation of carbon. The dry matter of potato tubers contains 2.3 per cent of potash, that of grapes 3 per cent, and of mangles 4 per cent. It is taken up by plants largely as nitrate, chloride, carbonate, sulphate, and phosphate. Most of our clays and loams and many sandy soils contain large amounts of potassium. This element is usually present in soil in comparatively insoluble minerals so that the amount which becomes soluble per season may be insufficient for maximum crop growth.

Alderman (1915) found that 1 pound muriate of potash per tree checked the growth of young peach trees slightly, 2 pounds were quite detrimental, and 2.5 pounds killed the tree. With the sulphate, vigor was not increased, but a larger quantity could be used without injury to the trees.

It has sometimes been thought that potash salts tend to increase color in fruits; but the indications are that, in most cases, this is due to the presence of less foliage on the potash fertilized trees allowing access of sunlight.

Whitten and Wiggans (1916) found that potash had no influence on the yield of apples or peaches, and that when used alone it gave less yield than the check. Potash and phosphoric acid combined also gave no increase in yield.

Dayton and Voorhees (1895) and Blake and Farley (1912) of the New Jersey Station found that muriate of potash, ground bone, and acid phosphate together gave greatly increased yields of apples of five varieties, but no increase with Baldwin. They also report an

increase in peaches due to potash. These experiments were made on a strong loam soil.

Stewart (1918) of the Pennsylvania Station reports increased yields in three orchards from potash alone or in combination, with some increase also in size of fruit, but in two other orchards it apparently had an injurious effect.

Hedrick and Gladwin (1914) of the New York Station found that potassium slightly increased the size of the grape leaf and the growth of wood.

Gourley (1914) of the New Hampshire Station also found that potash increased the size of fruit.

IMPORTANCE OF LIME

Lime has two important functions in the economy of the plant. The first has to do with the calcium metabolism of the plant, this element being one of the essential ones in growth. However, since comparatively few soils have so low a calcium content that plants suffer from calcium starvation, we will confine ourselves to the second important function, that of the influence of lime on soil reaction. This function is really not one of calcium at all but of the properties of calcium salts, such as the hydroxide and carbonate, in neutralizing acids or furnishing base. This same purpose is served by many other compounds; but as carbonate and hydroxide of calcium are the forms commonly used, the subject is discussed under the above heading. Very little is known regarding the effect of reaction of soil on trees. Many soils may have an acid reaction in their surface depth, but the reverse in their subsoil, so that the fact that trees grow on soil which has an acid reaction may not indicate that they are not susceptible to acidity.

It is a well known fact that many species of plants are highly susceptible to reaction of the medium, while others are quite tolerant, and still others actually thrive in a medium deficient in base.

About all the data we have on this subject as regards trees are some scattered observations. Table 2, giving the amounts of plant food used by fruit trees, indicates that lime in large quantity is used by trees, especially peach trees.

Rousseaux and Chappaz in France found that the grape vine removes more lime from a high lime soil than all other plant food combined. It removed three times as much lime as potash.

Carmody (1912) in Victoria states that it is a common observation that fruit buds of trees grown on sour soils are of weak or indefinite character, the bark is dry in appearance, and the growth more or less stunted. This is particularly true on heavy clays. On soils rich in lime the wood is matured earlier and fruit buds are more robust. He also states that it is recognized that trees are less prolific on soils deficient in lime. These observations were especially true of stone fruits.

Jenkins (1905) reports that the Connecticut Station used lime on peaches in a fertilizer experiment in progress since 1899. They found during several years that, altho peach yellows appeared in some of the plats, there was none found on the lime plats.

Dayton and Voorhees (1894), from 8 years' work with peaches, report a much smaller net increase of fruit on the manure and lime plat than on the plat receiving manure alone.

Alderman (1915) in work with peaches reports that the influence of lime could not be definitely determined, and must be regarded as largely negative, otherwise the production was somewhat increased.

Hedrick (1911) and Hedrick and Gladwin (1914) in fertilizer experiments with Rome Beauty apple trees and Concord grapes, state that lime was probably not a limiting factor in the experiments. In the experiment with grapes, lime did not affect the vines in the least.

Gourley (1914) found that, in a fertilizer experiment with apples, lime did not affect any of the factors considered in the experiment.

Stewart (1918) in extensive experiments with fertilizers on apple orchards, reports that lime has had no important influence on yield or growth.

USE OF MANURE IN ORCHARDS

It is frequently a common practice to use manure in orchards and in a number of fertilizer experiments a manure treatment has been included. Besides carrying considerable nitrogen and some potash and phosphoric acid, manure might also be expected to affect trees, either beneficially or otherwise, thru its organic matter content.

In a number of experiments, manure has usually had the same effect as other nitrogen carriers.

Garcia (1917) of the New Mexico Station, reports that peach trees treated with manure declined very materially and showed much chlorosis.

Ballou (1912) of the Ohio Station reports that stable manure, while of unquestioned value in the orchard, is much slower in its action than nitrate of soda or tankage.

Dayton and Voorhees (1895) report a large net increase in yield of peaches on a manured plat.

Stewart (1918), in fertilizer experiments with apples, found that manure usually secured a fair increase in size of fruit, due probably to its moisture conserving effect. Otherwise it acted very much like other nitrogen carriers.

Hedrick (1911) secured no significant increases in yield from manure on apples.

Undoubtedly the increase in moisture-holding capacity of a soil is one of the main values of manure in an orchard or other soil.

GENERAL CONCLUSIONS OF OTHER INVESTIGATORS

As regards the general practice of fertilizing orchards, the following conclusions have been drawn by a number of investigators, both as results of experiment and observation.

The Woburn Experimental Fruit Farm (1917) in England reports, after many years of experimental work, that apple trees grown in soils similar to those in which farm crops were grown did not respond favorably to manurial dressings of any kind.

Rivière and Bailbache (1914), in France, state that the indications are that complete fertilizers may retard rather than hasten the ripening period of pears.

Whitten and Wiggans (1915) report that in their orchard nutrition studies the peach was the only fruit which had so far shown an increase from fertilizers.

Alderman (1916) states that fertilizers would be wasted in many orchards especially when cultivated, while orchards in sod or low in vigor would respond to nitrogen and perhaps to phosphorus. In work with peaches on thin shale soil, Alderman (1915) concludes

that nitrogen is necessary, but that the benefit from phosphorus and potassium is questionable.

Neale (1894) states that one thing was apparent in their results with peaches, namely, that no one could advise fertilization of any kind in their orchard with the expectation of paying returns.

Holladay (1893) of the Virginia Station, in a fertilizer test on grapes, concludes that nitrogen, phosphorus, and potassium are all needed for the vine on their soil.

Blake (1909) recommends for peaches an annual application of 150 pounds per acre of muriate or sulphate of potash, 100 pounds of ground bone, and 200 pounds of acid phosphate.

Ballou (1912) fertilized a number of orchards in sod on the poorer soils of southern Ohio and greatly increased the returns. The trees responded more quickly to nitrogen than to phosphorus and potassium. He states that no results of value would accrue from fertilizing orchards on fertile soil which already contains sufficient plant food for growth and fruiting.

Brooks (1910) of the Massachusetts Station, in a 15 year experiment with apples of four varieties in sod, found that all fertilizers used greatly increased yield.

Hedrick (1907 and 1911) and Hedrick and Gladwin (1914) found that fertilizing a cultivated apple orchard on good soil did not pay; but in a vineyard, on soil of only fair fertility, nitrogen proved a limiting factor, but potassium and phosphorus were not profitable.

Stewart (1918), in a number of apple orchards mainly in sod and on a variety of soils, found that nitrogen and in some cases also potassium and phosphorus were valuable in increasing yield and growth. In one orchard, on poor soil, no kind of fertilization had paid up to the time of reporting results.

Gourley (1914), in a Baldwin apple orchard under cultivation, received no cash returns from money invested in fertilizers.

SUMMARY OF WORK OF OTHER INVESTIGATORS

In the foregoing discussion, among the many different results obtained and opinions cited, several striking observations may be made as follows:

1. That results from the fertilization of fruit trees have not been uniform.

2. That species of fruits apparently differ in their response to fertilizer treatment.

3. That conditions under which various results were obtained have been very different.

4. That the subject of orchard fertilization is not settled.

SOURCES OF ERROR IN ORCHARD FERTILIZATION EXPERIMENTS

In addition to the common sources of error affecting annual field crop experiments, the orchard is subject to many influences peculiarly its own including the following:

1. Non-uniformity of soil in large plats.
2. Differences in size, vigor, and character of trees.
3. Necessity of basing interpretations on a small population. Not many orchards in the State furnish the required number of trees on uniform soil which would permit of the use of a large number of trees for each treatment.
4. Difficulty of replication of treatments. When the plan of separating the treated rows by discard rows of trees is followed, replications are usually impossible on account of the limitations imposed by size of orchards and character of the soil.
5. Possible differences in productiveness of trees from unknown stock.
6. Uncertainties connected with cooperative experiments in which entire supervision by the experimenter is impossible.

Many of the influences affecting orchards operate in a more or less hit-and-miss fashion. For example, an insect infestation usually begins at a certain spot and spreads from there as a center; and this, even if checked promptly, often results in seriously and unequally affecting yields.

Carelessness in the usual operations of spraying may seriously affect uniformity of yield. Careless pickers may greatly increase the percentage of drop apples. In fact, there are many influences affecting results which are peculiar to orchard experiments.

PRESENT INVESTIGATION

DATA ON THE EXPERIMENTS

The various sites selected (Table 1) for the purpose of the experiments were examined carefully with the following requirements in view: Uniformity as to drainage, topography, and character of soil; uniformity as to age and vigor of trees; and with reference to previous management.

TABLE 1.— DATA ON THE EXPERIMENTS.

FRUIT	ORCHARD	LOCATION	NUMBER OF TREES	AGE OF TREES AT BEGINNING OF EXPERIMENT	YEAR EXPERIMENT BEGAN
Apple....	Densmore-Chapman...	Albion.......	264	38 years	1912
Apple....	Auchter-Vick & Dildine..............	Rochester....	230	37 years	1914
Apple....	Great Bear...........	Fulton.......	252	4 years	1913
Pear.....	Howard..............	Kinderhook...	504	Just set	1912
Peach....	King.................	Trumansburg.	500	8 years	1912
Cherry...	O'Neil...............	Geneva......	528	5-6 years	1913
Nursery stock, apples.	Smith Nursery........	Geneva......	6600	....	1912
Grape....	Stone Vineyard.......	Fredonia.....	4 acres	....	1912

Too many plat experiments have been made on land which, for various reasons, is unsuited to accurate work. The land from its very topography may be illy fitted for experimentation. Marked variations in topography mean differences in drainage and leaching. The frequent differences in fertility and moisture between high and low points in a field is a matter of common observation.

Contrary to general opinion, the plant food elements from various parts of even the most uniform field may vary, sometimes within wide limits. Waynick (1918) in a statistical study of the variability of a California soil especially with reference to nitrification, found that among 81 samples of surface soil taken systematically from what would generally be considered a very uniform plat, 100 feet in diameter, the nitrates varied widely. The extremes were 20 and 90 pounds nitrate nitrogen per acre six inches, while the subsoil to a depth of 24 inches varied even more. Biochemical factors, as evidenced by nitrate production, varied within still wider limits.

Such variations in an apparently uniform plat would indicate the importance of securing the greatest uniformity possible in texture and fertility of soil for plat experiments.

In selection of trees, attention must be given to uniformity in vigor and size. A sufficient number of trees should be averaged to make comparison justifiable. After these factors are considered, there still remains the very important one of individuality of trees. As the selection of stock and planting of the orchards in no case was under the control of the investigator in these experiments, this factor may be an operative one.

Some trees under similar conditions seem to produce better than others. Of course this may have nothing to do with tree individuality and may be due to other causes, but the fact remains that one tree may produce 15 barrels of apples while another next to it of similar size and vigor may produce 5 barrels.

In this connection Woods (1918) found that in a Ben Davis orchard there were three rather definite types of trees. One was stocky with large limbs and many fruit spurs; a second was quite different in having no large main branches, but with the head made up of many long slender limbs with the bearing wood at the ends; and a third type comprising an intermediate form. He found that these three types bore differently thruout the experiment. In fact so marked was the difference that some of the trees had to be discarded in writing up the results. We assume, of course, that in a reasonable period of years these inequalities as between trees and plats are balanced, but are they always balanced?

The foregoing facts emphasize the importance of care in selection and the necessity of repetition for a long period of years before any differences between plats can be regarded as significant.

The report on the experiments here described must be considered as an account of progress only, and as merely indicative of what these orchards may be expected to do under this plan of fertilization. The next five years' results may greatly alter the conclusions drawn.

One other fact should be mentioned here, namely, the influence of variety or varietal difference. It may not always be safe to compare results in fertility tests on different varieties as these may differ in their response to fertilizers. To illustrate this point, in 1896 the New Jersey Station began an experiment on fertilizing apple

trees. Two trees of each of six varieties growing on a strong loam sod were chosen, and were given 500 pounds per acre annually of a mixture of equal parts ground bone, acid phosphate, and muriate of potash. Another set of two trees each of the six varieties were given the same treatment with the addition of 150 pounds nitrate of soda per acre. A third set received no fertilizer. The trees began to bear in 1901. The varieties were Smith Cider, Baldwin, King, Jonathan, Oldenburg, and Gravenstein. Blake and Farley (1912) report that phosphorus and potash increased the yield of all varieties except Baldwin. The addition of nitrogen gave a further increase with Gravenstein and Baldwin, altho the yield of the latter was still far below that of the plat receiving no fertilizer. In the other four varieties nitrogen apparently decreased the yield. Altho these results are from very limited experiments, they are suggestive.

PLAN OF PLATS AND TREATMENT

In adopting any plan of treatment in a plat experiment some basis must be sought for the determination of what such treatments shall be. Precedent is not always a safe guide. Experiments have

TABLE 2.— FERTILIZING CONSTITUENTS REMOVED BY FRUITS, POUNDS PER ACRE.

Crop	Fertilizing constituents			
	N	P_2O_5	K_2O	CaO
Apple, total	54	14	62	57.0
" fruit only	14	7	41	4.0
" nursery stock	29	10	20	....
Peach, total	63	18	62	114.0
" fruit only	20	8	39	1.6
" nursery stock	22	5	12	....
Pear, total	30	7	33	3.8
" fruit only	10	7	28	2.2
" nursery stock	25	8	13	....
Plum, total	30	9	38	41.0
" fruit only	13	5	19	4.4
" nursery stock	20	4	12	....
Grape, fruit only	12	6	24	....
" prunings	4	1	4	....
Wheat, 20 bu. plus 1½ tons straw	42	14	20	9.0

been few or lacking altogether, and general practice varies from no fertilizer to large quantities, so that it seems desirable to look for some other factors to serve as a basis of fertilizing practice.

Some light is thrown on this question by a study of the amount of plant food removed from an acre by various fruits. In looking up this subject, data from various sources have been brought together, averaged in some cases, and Table 2 compiled. The fertilizing constituents in a crop of wheat of 20 bushels grain and 1½ tons straw is given for comparison. The apple, pear, and peach crop is figured on a basis of about 20,000 to 25,000 pounds per acre. Such a table gives one an appreciation of the fact that fruit trees remove large amounts of plant food from the soil.

GENERAL PLAN OF TREATMENT

In drawing up the plan given below (Fig. 1), it was thought that taking into consideration other experiments, the composition of crop

No. of Plat	
1.	45 lbs. nitrogen from nitrate of soda. 25 lbs. phosphorus from acid phosphate. 100 lbs. potassium from muriate of potash.
2.	No treatment.
3.	45 lbs. nitrogen from nitrate of soda. 40 lbs. phosphorus from acid phosphate. 50 lbs. potassium from muriate of potash.
4.	45 lbs. nitrogen from nitrate of soda. 40 lbs. phosphorus from acid phosphate.
5.	45 lbs. nitrogen from nitrate of soda.
6.	No treatment.
7.	40 lbs. phosphorus from acid phosphate. 50 lbs. potassium from muriate of potash.
8.	40 lbs. phosphorus from basic slag. 50 lbs potassium from muriate of potash.
9.	120 lbs. phosphorus from raw rock phosphate. 50 lbs. potassium from muriate of potash.
10.	No treatment.
11.	40 lbs. phosphorus from acid phosphate. 2 tons ground limestone once in 3 years.

FIG. 1.— ARRANGEMENT AND GENERAL TREATMENT OF THE PLATS.

removed, and general fertilizer practice, the amounts of plant food given in each case represented a sufficient amount for full crop production and for fertility maintenance.

It should be explained that, owing to the high price and scarcity of potash salts during the period of the war, no potash was applied to these orchards during 1916 and 1917. During these two years also, dried blood was substituted for nitrate of soda.

As it was considered desirable to carry out the general rule of having every treated and check plat protected on each side by a discard row of trees, thus preventing the carrying over of fertilizer, practically twice the number of tree rows was necessary, so that the problem of securing an orchard large enough and uniform enough was doubled. This rule also made it necessary to limit the number of treatments to those given in the outline. In fact, in several cases the full 11 plats were not obtainable. It would have been interesting and desirable to have included a manure plat and possibly some others in the experiments, if this could have been done.

The general cultural conditions are described under the sections devoted to each orchard. In cooperative experiments there is always some uncertainty and considerable dissatisfaction, due to lack of personal supervision of all orchard operations. These experiments have not proved an exception in this regard. Two of the orchards changed management during the time reported on. The general plan has been to supervise personally the application of fertilizers and the taking of fruit and growth records. Pruning, culture, and spraying have been entirely in the hands of the cooperators.

METHODS OF TAKING RECORDS

Since accurate record taking requires a large amount of time and money, and since several of these orchards are long distances from Geneva, it was considered advisable to make use of two factors only, namely, increase in trunk diameter and yields of fruit. The former is thought to be a fair index of tree vigor and growth, and the latter of performance.

No one realizes more fully than the author the great value of more extensive records, such as production of new wood, leaf area, nitrate production in the plats, etc., but it was considered impossible to give the time required for such extensive records.

EXPERIMENTS WITH THE APPLE

EXPERIMENT IN THE DENSMORE-CHAPMAN ORCHARD

The Densmore-Chapman orchard is a Baldwin apple orchard and was 38 years old in 1912 when the experiment began. It is located about 2½ miles northeast of Albion on a very level and uniform piece of land with good natural drainage. The soil is a reddish loam with considerable sand, is easy to work, and is in a good state of fertility. The subsoil is very similar. An analysis of the soil in this orchard is given in Table 3.

TABLE 3.— ANALYSIS OF SOIL IN DENSMORE-CHAPMAN ORCHARD. Average of check plats, 1912.

CONSTITUENTS	0–7 INCHES		7–14 INCHES	14–21 INCHES
	Per cent	Pounds in 1 acre	Per cent	Per cent
Nitrogen	0.102	2,040	0.069	0.048
Phosphorus	0.066	1,320	0.063	0.058
Potassium	1.46	29,200	1.46	....
Calcium	0.48	9,600	0.46	0.39
Magnesium	0.35	7,000	0.39	0.33
CO_2 calculated to calcium carbonate	0.079	1,580	0.73	0.45
Total carbon	1.74	34,800	....	....

In order to make this table and subsequent tables of soil analyses intelligible, it is necessary to give a brief explanation. Altho chemical analysis of soil does not give reliable data upon which to base agricultural practice, nevertheless, soil analysis carried out on a large scale with certain definite plans in view is very suggestive. This has been shown to be true by Hilgard working over a long period of years and in various humid and arid regions of the United States. Hilgard's conclusions have been verified in a striking manner by Liebscher and Maerchker in Germany, and also by agricultural chemists in France, Russia, and England.

For purposes of comparison, the writer has made up Table 4 representing the average analyses of some 75 soils taken from various parts of the fruit belt of New York. The analyses are from some unpublished data of the Department of Agronomy, and refer in all cases to the first 7 inches of soil.

TABLE 4.— AVERAGE ANALYSES OF 75 SOILS FROM FRUIT BELT OF NEW YORK.

CONSTITUENTS	PER CENT	POUNDS PER ACRE 7 INCHES
Nitrogen	0.150	3,000
Phosphorus	0.069	1,380
Potassium	1.700	34,000
Calcium	0.549	10,980
Magnesium	0.477	9,540
CO_2 as $CaCO_3$	0.251	5,020
Total carbon	1.740	34,800

It is generally considered that the percentages of constituents given in Table 5 make up a very fertile soil.

TABLE 5.— CONSTITUENTS OF A FERTILE SOIL.

CONSTITUENTS	PER CENT	POUNDS PER ACRE 7 INCHES
Nitrogen	0.3	6,000
Phosphorus	0.1	2,000
Potassium	1.5	30,000
Calcium	0.5	10,000

In comparing these average analyses with our type soil, we find that the fruit belt soils are much lower in nitrogen and considerably lower in phosphorus, but compare very favorably in potassium and calcium. Of course, there are many soils of high fertility containing much less nitrogen and phosphorus than our type soil. In fact, the average analysis of fruit soils given above compares not unfavorably with the available averages for analyses of soils of the corn belt of Missouri, Iowa, and Kansas.

The trees in this orchard were originally set 33 by 33 feet, but several years before the experiment began, all but eight rows in the block were thinned to stand approximately 47 by 66 feet. The other eight rows of trees stood 33 by 33 feet and were considerably crowded until 1918 when they also were thinned. The trees previously thinned have attained great size. The general plan of the orchard is shown in Fig. 2.

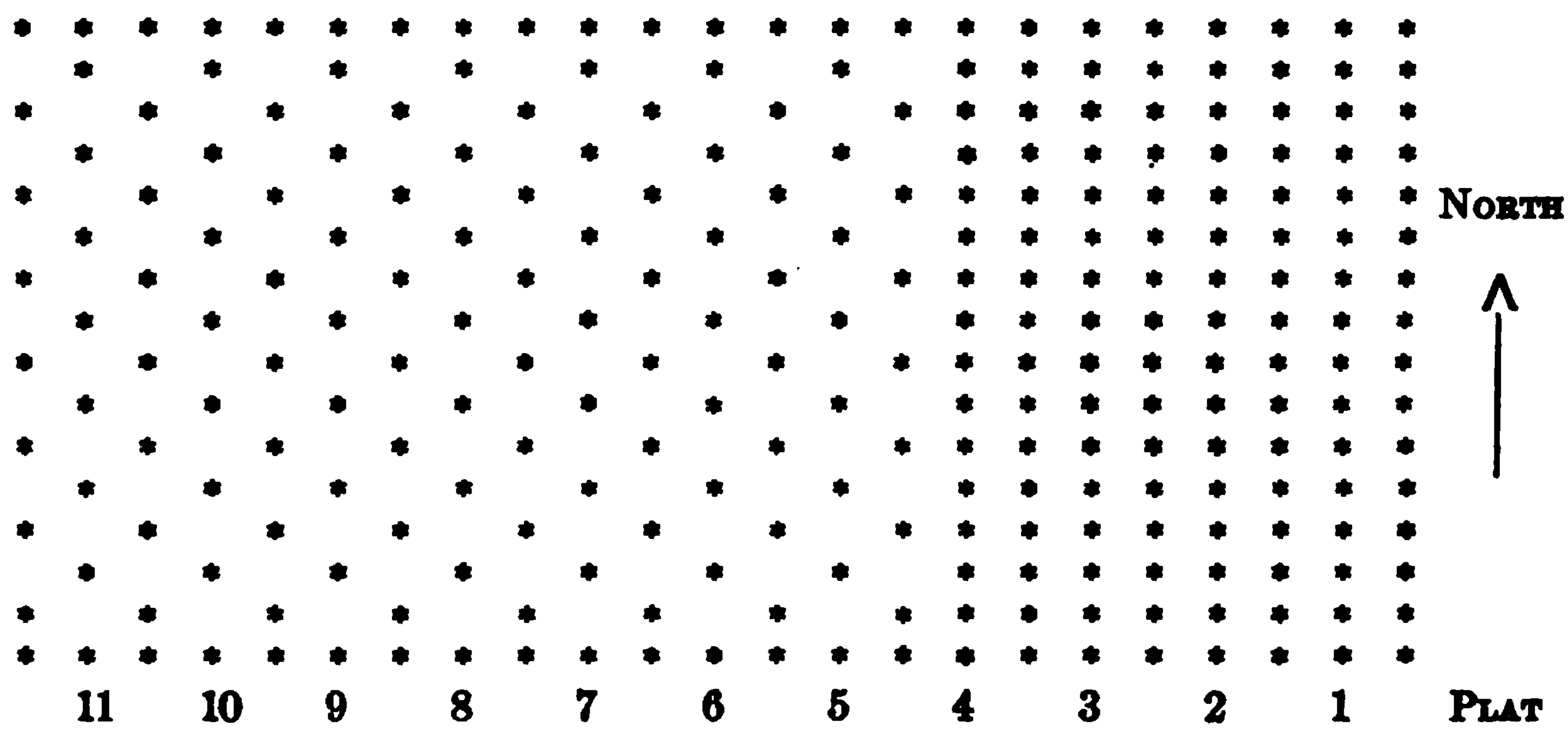


FIG. 2.— PLAN OF DENSMORE-CHAPMAN ORCHARD, 1912.

Until 1910 this orchard was in sod, and up to that time received about 10 loads of manure once in two years. It was then plowed up and clean culture maintained except as noted below. Pruning has been rather light and confined mainly to dead and interfering wood. More pruning would be beneficial. Spraying has been regularly maintained.

In 1912, 1913, and 1914, red clover was used as a cover crop; in 1915, 1916, and 1917 alfalfa; and in 1918 alsike clover was used. In 1919 no cover crop was sown. The large trees so shade the ground that it is difficult, if not impossible, to get a satisfactory growth of a legume cover. Other cover crops of the non-legumes will be tried.

During 1913 to 1916 the practice of dividing the orchard into two equal divisions cross-wise of the plats was followed, allowing the cover crop to remain one year on the north half, while the same year the south half was clean cultivated. A cover crop was then sown on this south half in the late summer. The following spring the whole orchard was plowed and tilled during the season, and the

cover crop sown as usual; while the next spring the south half was left and the north half tilled, etc. The whole orchard, however, was tilled in 1916, 1917, 1918, and 1919.

The orchard bore only fairly well up to 1908. From 1908 to 1912 the average for the block was about 300 barrels per year. The crop was very light in 1911.

In recording the results (Table 6), no attempt will be made to give the data by individual trees, since such a method would be cumbersome and would prolong the tables unnecessarily. Yields will be given for whole plats for each year, and the growth increase for the total period under discussion.

TABLE 6.—YIELD OF FRUIT IN DENSMORE-CHAPMAN ORCHARD.

Bushels per plat.

PLAT NO.	TREATMENT	YEAR					TOTAL, 1912–19	TOTAL AVERAGE PER TREE	TOTAL INCREASE OVER NEAREST CHECK, 5 CROPS	TOTAL INCREASE OR DECREASE OVER NEAREST CHECK, 3 LARGEST CROPS
		1912	1913	1914	1916	1918				
		Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
1	N-P-K......	317.0	87.0	312.6	40.0	282.2	1038.8	78.7	+41.0	—3.0
2	Nothing.....	325.8	39.0	321.0	44.0	268.0	997.8	76.8	....	....
3	N-P-K......	359.6	50.0	300.0	44.0	246.5	1000.1	79.3	+12.3	—8.7
4	N-P-O......	386.5	21.0	351.9	54.0	288.5	1101.9	77.1	+104.1	+112.1
5	N-O-O......	316.3	32.0	318.0	27.0	359.0	1052.3	116.9	+131.7	+141.7
6	Nothing.....	276.6	33.0	270.0	36.0	305.0	920.6	106.4	....	....
7	O-P-K......	269.8	21.0	319.2	36.0	342.2	988.2	109.8	+67.6	+79.6
8	O-P-K......	244.7	18.0	308.4	37.5	301.6	910.2	101.2	—38.2	—33.2
9	O-P-K......	248.3	31.5	265.8	39.0	274.0	858.6	107.4	—117.6	—136.1
10	Nothing.....	297.2	11.0	342.0	41.0	285.0	976.2	108.6	....	....
11	$CaCO_3$-P....	279.3	10.0	312.0	32.0	257.7	891.0	98.6	—85.2	—75.2

Since in Plats 1, 2, 3, and 4, the trees were still 33 by 33 feet up to 1918, the total yields on these plats, with the exception of 1918, are for 15 to 16 trees, while on all the other plats the totals are for 8 to 9 trees. This fact renders the results not strictly comparable; but Plats 1, 2, 3, and 4 are comparable with each other, also Plats 5 to 11 are comparable with each other.

The tree averages are the sum of the individual averages for each crop year.

Up to the present time this orchard cannot be called a productive one with only three fair crops in eight years.

In comparing the annual yields obtained, plat by plat, during the three heavier crop years, it will be seen that on the four 15- to 16-tree

plats (Plats 1, 2, 3, and 4) the nitrogen and phosphorus plat yielded the best all three years; while the yields of the other three plats were erratic, the check yielding better than either of the complete fertilizer plats one year, and better than one or the other each of the other two years.

If Plat 5 receiving nitrogen only is included in this comparison, it will be seen that, altho it is a 9-tree plat, it has outyielded the 15 to 16 trees on either of the complete fertilizer plats, and compares well with the nitrogen and phosphorus plat.

If these plats are compared in another way, using the increases in yields over the nearest checks, it is impossible to find a normal check yield with which to compare Plat 4, since the check on one side is a 16-tree plat and that on the other side a 9-tree plat.

However, using Plat 2 as a check on Plats 5 and 7, and comparing the differences for the three years of large crops only, we find that the check has produced 3 bushels more than one complete fertilizer plat, and 8.7 bushels more than the other; while the nitrogen and phosphorus plat has produced 112.1 bushels more than its check, the nitrogen only plat 141.7 bushels more, and the acid phosphate and potash plat 79.6 bushels more.

Comparing the increases over the nearest checks for the five crops, the results are somewhat different for here all the five plats have produced more than their checks. In other words, the yields for the two lean years reverse the result in two cases. It is undoubtedly safer, in this case, to use the figures for total yield for the whole period, certainly at least from a financial standpoint, since many times low yields mean high prices; altho, on the other hand, the cost of production in the lean year is increased.

When we come to results due to the different forms of phosphorus, Plats 7, 8, and 9 are comparable.

Seemingly, basic slag and raw rock phosphate are inferior to acid phosphate, while the limestone plat has given a considerably lower yield than its check.

The results on this orchard in regard to yields have been gone into at some length in order to illustrate the difficulty of experimentation of this kind with fruit trees. The results are erratic, not at all clean cut, and while it appears that in a general way nitrogen alone or combinations containing nitrogen have increased

yields, the comparisons between the combinations themselves have been so peculiar that all that can be said is that in this particular orchard the value of fertilization has not been proved. We must have more data before any conclusions can be drawn.

Data are also available for 1912, 1913, 1914, and 1916 on the yields of first grade fruit and culls (Table 7). The first class fruit is here lumped in one grade and called barreled fruit, while the cider apple grade includes culls and drops.

TABLE 7.— YIELDS OF BARRELED FRUIT AND CIDER APPLES IN DENSMORE-CHAPMAN ORCHARD.

Total bushels per plat, 4 crops.

PLAT NO.	TREATMENT	TOTAL PER PLAT		INCREASE OR DECREASE IN BARRELED FRUIT OVER NEAREST CHECK	PERCENTAGE OF GOOD FRUIT
		Barreled	Cider apples		
		Bushels	*Bushels*	*Bushels*	*Per cent*
1.....	N-P-K..................	541.2	215.5	—47.6	71.5
2.....	Nothing..................	588.8	140.7	....	80.7
3.....	N-P-K..................	575.3	178.2	—13.5	76.3
4.....	N-P-O..................	653.7	160.0	+64.9	80.3
5.....	N-O-O..................	545.5	148.0	+45.7	78.7
6.....	Nothing..................	499.8	116.0	....	81.2
7.....	O-P-K..................	524.0	122.2	+24.2	81.1
8.....	O-P-K..................	485.7	120.0	—31.6	80.2
9.....	O-P-K..................	464.3	120.5	—70.6	79.4
10.....	Nothing..................	534.9	156.5	....	77.4
11.....	$CaCO_3$-P..................	498.3	135.0	—36.6	78.7

The results are so inconsistent that no conclusions can be drawn. Fertilizers up to the present have neither increased the percentage of first class fruit nor influenced the number of culls.

With regard to size of fruit, data are available for the three years of largest crops. The apples were counted from average barrels as picked, and from 9 to 16 barrels from each plat were averaged. The figures in Table 8 show the average number of apples per barrel for the three crops.

There is nothing striking in this table that would indicate that size of fruit is affected by fertilizers, with the possible exception

of Plat 11. The average size of the fruit of this particular plat was decreased due to the production of a high percentage of small apples in 1918. This fact has not been accounted for.

TABLE 8.— AVERAGE NUMBER OF APPLES PER BARREL FOR THREE CROPS, DENSMORE-CHAPMAN ORCHARD.

PLAT NO.	TREATMENT	AVERAGE NUMBER APPLES PER BARREL
1	N-P-K	541
2	Nothing	514
3	N-P-K	515
4	N-P-O	522
5	N-O-O	552
6	Nothing	529
7	O-P-K	529
8	O-P-K	534
9	O-P-K	518
10	Nothing	539
11	$CaCO_3$-P	579

It has been the custom in this orchard to examine the general run of fruit during harvest for differences in color. No marked differences have been noted which could be attributed to fertilizer treatment. During one season it was thought that the fruit on the plat receiving limestone and acid phosphate was more highly colored, but this was noticeable only one season and might have been due to other causes.

There have been minor differences noted in color and quantity of foliage. It has several times been noted that those plats receiving nitrogen seemed to have somewhat more abundant and darker green foliage. These observations have not always been consistent, however.

In taking growth records the diameter of the trunk was taken at the beginning of the experimental period and again in the fall of 1919. (See Table 9.) The figures used are for approximate mid-trunk diameter, secured by averaging two measurements, one taken fairly low and the other 1½ feet higher. The lower one was usually made 1½ feet from the ground and the other 3 feet from the ground. In some cases this varied with conditions in order to secure what was thought to represent most nearly mid-trunk diameter.

TABLE 9.— INCREASE IN TRUNK DIAMETERS, DENSMORE-CHAPMAN ORCHARD, 1912–1920.

Averages per tree.

PLAT NO.	TREATMENT	AVERAGE MID-TRUNK DIAMETER		INCREASE IN DIAMETER, 1912–1920	INCREASE OVER CHECK
		1912	1919		
		Inches	*Inches*	*Inches*	*Inches*
1	N-P-K	16.2	18.5	2.3	0.20
2	Nothing	17.0	19.1	2.1	....
3	N-P-K	16.2	18.6	2.4	0.30
4	N-P-O	16.9	19.3	2.4	[a]0.30
5	N-O-O	17.9	20.7	2.8	0.30
6	Nothing	18.1	20.6	2.5	....
7	O-P-K	18.3	21.0	2.7	0.20
8	O-P-K	17.6	20.4	2.8	0.15
9	O-P-K	17.3	20.1	2.8	0.00
10	Nothing	18.0	20.8	2.8	....
11	$CaCO_3$-P	18.2	21.0	2.8	0.00

[a]Plat 2 is used as a check on Plat 4.

From the table it appears that growth has been somewhat increased by fertilization, altho the increases over the checks are small. Nitrogen seems to have rather consistently increased diameter slightly.

As a summary of the results secured with the Densmore-Chapman orchard, it may be said that fertilization has not produced results which would justify the necessary outlay for fertilizers and the labor involved in their application. Yield, which is the important factor with the orchardist, has not been consistently increased. There has been no marked improvement in color or size of fruit, and growth increases have been very small. Fertilization has not been worth while in this orchard up to date.

EXPERIMENT IN THE VICK AND DILDINE ORCHARD

The Vick and Dildine orchard is a Baldwin apple orchard and was 38 years old at the beginning of the experiment in 1914. It is located a few miles west of Rochester near South Greece, and is perhaps best known as the Auchter orchard. From 1903 to 1913 it was used in a sod and tillage experiment by the Department of Horticulture. This work has been published from this Station as Bulletin No. 314. As an accurate record of the orchard's perform-

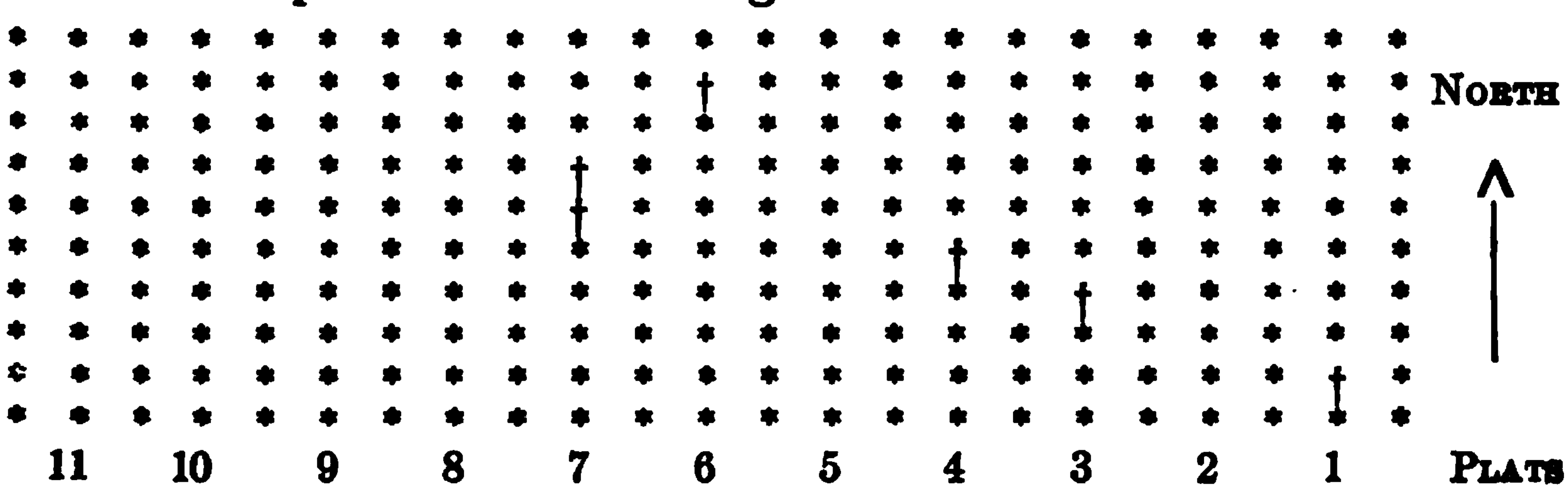
ance for 10 years was available, it was thought that it would be admirably adapted to a fertility experiment.

The orchard is located on a uniform piece of land as regards soil. Altho not level, the land slopes very gently both ways from the center of the orchard so that the rows of trees running across this slope are quite comparable. The only marked variation in topography is located in the south-west corner which is some 12 to 14 feet lower in elevation. This area, however, has been discarded in the fertilizer experiment. An analysis of the soil in this orchard is given in Table 10. This analysis compares very favorably with the type analysis on page 70. The soil is low in carbonates, but fairly well supplied with nitrogen, phosphorus, and potash.

TABLE 10.— ANALYSIS OF SOIL IN VICK AND DILDINE ORCHARD.
Average of check plats, 1914.

CONSTITUENTS	0-7 INCHES		7-14 INCHES
	Per cent	Pounds per acre 7 inches	Per cent
Nitrogen	0.15	3,000	0.11
Phosphorus	0.059	1,180	0.051
Potassium	1.34	26,800	1.69
Calcium	0.54	10,800	0.50
Magnesium	0.30	6,000	0.29
$CaCO_3$ from CO_2	0.067	1,340	0.054
Total carbon	1.82	36,400	1.28

The trees in the orchard are 40 by 40 feet and the general arrangement of the plats is shown in Fig. 3.[1]



† Tree not used in average — missing or replant.

FIG. 3.— PLAN OF PLATS IN VICK AND DILDINE ORCHARD, 1914.

[1] For previous treatment and care of orchard see N. Y. Agr. Exp. Sta. Bul. 314, 90-94. 1909.

Red clover has been used as a cover in this orchard, and the practice of leaving one-half of the orchard in clover during alternate years has been followed up to 1919. In 1914, 1916, 1918, and 1919 the whole orchard was tilled, in 1915 the south half was left in clover, and in 1917 the north half was left in clover. The clover has made fairly good growth each year. This orchard has been fairly productive but not phenomenally so by any means.[1]

TABLE 11.— YIELD OF FRUIT IN VICK AND DILDINE ORCHARD.

Bushels per plat.

PLAT NO.	TREATMENT	YEAR					TOTAL YIELD, 6 YEARS	TOTAL AVERAGE PER TREE	INCREASE OR DECREASE OVER NEAREST CHECK
		1914	1915	1916	1918	1919			
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1	N . . .	104	110	152	94	159	619	68 8	+5.0
2	N	203	80	127	113	115	638	63 8	. . . . . .
3	N	131	19	94	120	111	475	52.8	—11 0
4	N	232	24	89	123	60	528	58 7	+1 2
5	N . .	222	16	74	106	61	479	47.9	—3.2
6	N . . .	195	24	94	86	61	460	51.1	. . . .
7	O	193	56	67	84	59	469	57.4	+6.3
8	O	164	93	81	206	81	625	62.5	—0.2
9	O	277	212	66	204	144	903	90.3	+16.1
10	N	213	134	124	164	107	742	74.2	. . . .
11	C	239	187	131	177	120	854	85.4	+11.2

The yields recorded in Table 11 are erratic, fertilizers having apparently increased yields in five cases and decreased them in three cases. The results, however, are inconsistent when the treatments are compared. Thus complete fertilizer in one proportion apparently increased the yield, and in another proportion decreased it. It is not considered necessary to go into the results in detail. A careful examination of the data will lead to the conclusion that the different increases over the checks have evidently been due to some factor other than fertilizers.

From the data given in Table 12 very little connection can be seen between fertilizer treatment and the percentage of good fruit and culls. It appears that the complete fertilizer plats have some 6 per cent more first grade fruit; but this does not hold for the other nitrogen plats, while the other fertilized plats show very little difference. No data on size or color of fruit are available.

[1] For further information concerning this orchard see N. Y. Agr. Exp. Sta. Bul. 376, 1914.

TABLE 12.— YIELD OF BARRELED FRUIT AND CIDER APPLES IN VICK AND DILDINE ORCHARD.

Bushels per plat, 5 crops.

PLAT NO.	TREATMENT	TOTAL PER PLAT, 6 YEARS		AVERAGE PER TREE		INCREASE OR DECREASE PER TREE OVER CHECK, BARRELED	PERCENTAGE OF BARRELED APPLES
		Barreled	Cider	Barreled	Cider		
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Per cent*
1	N-P-K.......	504	115	56.0	12.8	+5.9	81.4
2	Nothing.......	501	137	50.1	13.7	....	75.4
3	N-P-K.......	387	88	43.0	9.8	—7.1	81.5
4	N-P-O........	405	123	45.0	13.7	—1.1	76.7
5	N-O-O.......	387	92	38.7	9.2	—3.3	80.8
6	Nothing.......	378	82	42.0	9.1	....	82.2
7	O-P-K........	381	78	47.6	9.8	+5.6	83.0
8	O-P-K........	525	100	52.5	10.0	—0.1	84.0
9	O-P-K.......	786	117	78.6	11.7	+15.3	87.0
10	Nothing.......	633	109	63.3	10.9	....	85.3
11	$CaCO_3$-P......	714	140	71.4	14.0	+8.1	83.6

It appears from the data in Table 13 that nitrogen has increased trunk growth to a small extent, while phosphorus in three forms with potash has had no effect. The last two columns of the table have been inserted for comparison. As this orchard was under a sod and tillage experiment for ten years previous to 1913, the growth increases are available. It will be seen that the three rows of trees used as check plats are low for the period of 1908–1913. Plat 5 received potash and phosphorus during the period of 1908–1913, in the sod and tillage experiment. Plat 7 received phosphorus alone, and Plat 9 received potash alone during the same period.

During the fertilizer experiment, from 1913 to 1919, five of the treated plats actually made less diameter increase over their checks than did the same rows during the previous five years when under no fertilizer test, that is when these rows are compared with the rows used as checks in the present fertilizer experiment. The only striking fact noticeable in the seven years' results with the orchard, is the apparent non-response to fertilization in general. It appears that the accidental and chance differences in results have been greater than any differences attributable to fertilizers.

TABLE 13.— INCREASE IN TRUNK DIAMETER, VICK AND DILDINE ORCHARD, 1913–1919.

Averages per tree.

Plat No.	Treatment	Average mid-trunk diameter 1913	Average mid-trunk diameter 1919	Increase in diameter, 1913–1919	Increase over nearest check, 1913–19	Increase in diameter 1908–1913	Increase or decrease over plats used as checks, 1908–1913
		Inches	Inches	Inches	Inches	Inches	Inches
1	N-P-K......	16.8	18.9	2.1	+0.2	1.1	—0.10
2	Nothing......	17.1	19.0	1.9	....	1.2	....
3	N-P-K......	17.4	19.7	2.3	+0.4	1.7	+0.50
4	N-P-O......	17.4	19.5	2.1	+0.1	2.0	+0.70
5	N-O-O......	16.0	18.3	2.3	+0.2	1.7	+0.30
6	Nothing......	16.0	18.1	2.1	....	1.4	....
7	O-P-K......	18.0	20.1	2.1	0.0	2.2	+0.80
8	O-P-K......	17.3	19.3	2.0	0.0	2.1	+0.65
9	O-P-K......	16.8	18.6	1.8	—0.1	1.4	—0.30
10	Nothing......	17.2	19.1	1.9	....	1.7	....
11	$CaCO_3$-P.....	16.9	19.4	2.5	+0.6	2.2	+0.50

EXPERIMENT IN THE GREAT BEAR ORCHARD

The Great Bear orchard is a Northern Spy orchard and was 4 years old in the fall of 1913. The experiment began in the spring of the same year. The trees are 40 by 40 feet. The orchard is located south of Fulton on the farm of the Great Bear Springs

TABLE 14.— ANALYSIS OF SOIL IN GREAT BEAR ORCHARD.

Average of check plats, 1913.

Constituents	0–7 Inches: Per cent	0–7 Inches: Pounds in acre 7 inches	7–14 Inches: Per cent
Nitrogen..................................	0.18	3,600	0.08
Phosphorus..................................	0.89	17,800	0.071
Potassium..................................	1.37	27,400	1.13
Calcium..................................	0.41	8,200	0.42
Magnesium..................................	0.31	6,200	0.36
$CaCO_3$ from CO_2..........................	0.060	1,200	0.047
Total carbon..................................	1.99	39,800	1.02

Company, and is on a uniform piece of land and has good drainage. The soil is a stony, sandy loam with a sand and gravel subsoil. An analysis of the soil is given in Table 14.

This soil, altho quite stony, seems to be somewhat above the average in certain constituents. Carbonates and potassium are low, while the nitrogen and phosphorus percentages are good. This orchard has not yet borne a crop of apples. It has not been systematically tilled. During 1913 and 1914 it was left in sod, with the exception of a six foot strip next to the trees. In 1915 a crop of beans was harvested from the orchard. In 1916 oats were sown but a poor crop resulted. In 1917 and 1918 the conditions of 1913 were duplicated. In 1919 the orchard was plowed and planted to sweet corn. The orchard has not had the care that a young orchard should have, however, the trees are of good size and vigor, and have made good growth. Since this orchard has not yet borne fruit, the only results available for the seven years are those for diameter increase.

Up to 1917 a slight variation of the general fertilizer plan was used in which Plat 1 was omitted. From 1917 on, the plan was enlarged and in 1919 somewhat further enlarged, making use of some of the discard rows for treated plats. This was thought advisable and also feasable on account of the distance apart of the trees and their age. The present plan is shown in Fig. 4.

No. of plat	
1.	No treatment.
2.	45 lbs. nitrogen from nitrate of soda.* 40 lbs. phosphorus from acid phosphate. 50 lbs. potassium from muriate.
3.	No treatment.
4.	45 lbs. nitrogen from nitrate of soda. 40 lbs. phosphorus from acid phosphate.
5.	No treatment.
6.	90 lbs. nitrogen from nitrate of soda. 80 lbs. phosphorus from acid phosphate. 100 lbs. potassium from muriate.
7.	No treatment.
8.	45 lbs. nitrogen from nitrate of soda.
9.	No treatment.
10.	40 lbs. phosphorus from acid phosphate. 50 lbs. potassium from muriate.
11.	No treatment.
12.	2 tons limestone.
13.	No treatment.
14.	45 lbs. nitrogen from nitrate of soda. 40 lbs. phosphorus from basic slag. 50 lbs. potassium from muriate.
15.	No treatment.
16.	45 lbs. nitrogen from nitrate of soda. 120 lbs. phosphorus from rock phosphate. 50 lbs. potassium from muriate.
17.	No treatment.
18.	40 lbs. phosphorus from acid phosphate. 2 tons limestone.
19.	No treatment.
20.	90 lbs. nitrogen from nitrate of soda.

* Pounds per acre.

FIG. 4.— PLAN OF FERTILIZATION IN GREAT BEAR ORCHARD, 1917–1919.

Up to 1916 the nitrogen and potassium were applied to 20-foot circles around each tree, and the phosphorus and limestone to one-half the total area. From 1916 on, all fertilizers were applied to one-half the total area. In Table 15 results are given for the diameter increase under the original fertilizer plan only.

Table 15.— Increase in Trunk Diameter, Great Bear Orchard, 1913–1919.

Average per tree.

Plat no.	Treatment	Average mid-trunk diameter			Increase, 1913–15	Increase, 1913–19	Increase over nearest check, 1913–19
		1913	1915	1919			
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1	N-P-K.......	1.46	2.57	4.17	1.11	2.71	0.26
2	N-P-O........	1.23	2.41	4.10	1.18	2.87	0.42
3	Nothing.......	1.27	2.33	3.72	1.06	2.45	....
4	N-O-O.......	1.37	2.49	3.90	1.12	2.53	0.08
5	O-P-K........	1.26	2.30	3.43	1.04	2.17	0.17
6	Nothing.......	1.25	2.24	3.25	0.99	2.00	....
7	O-P-K........	1.41	2.47	3.94	1.06	2.53	0.53
8	O-P-K........	1.40	2.57	3.98	1.17	2.58	0.19
9	Nothing.......	1.45	2.49	3.84	1.04	2.39	....
10	$CaCO_3$-P.....	1.49	2.65	4.09	1.16	2.60	0.21

The measurements shown in the table were taken uniformly 15 inches from the ground. As the first tree in each row was just set out at the time the experiment began, it is not included in the averages. The figures are for the averages of 11 trees.

There appears to be an increase in growth on all fertilized plats. This increase amounts to 0.26 inches per tree as an average over the checks for the seven years. This is small, to be sure, but appears to be quite definite. The increased growth also seems to have taken place from the start since the figures for 1915 show the same tendency, the average being 0.86 inches for the three years, 1913 to 1915. When we compare the effect of various combinations of fertilizers, the increases are not consistent. Phosphorus has apparently increased growth more than has nitrogen alone. Basic slag has increased growth more than acid phosphate or rock phosphate.

This orchard is young, in good condition, and something may be expected from it when it begins to bear fruit.

EXPERIMENTS WITH CHERRIES

There seems to have been very little systematic work done on the fertilization of cherries. Blake and Farley (1910) report some small experiments on the effects of nitrate of soda on cherries, plums, apples, and pears. In this experiment, which ran from 1896 and was reported on in 1909, there were two trees of each of three varieties, Early Richmond, Louis Phillippe, and Montmorency. All plats received a basal treatment of 500 pounds per acre annually of a mixture of equal parts of ground bone, acid phosphate, and muriate of potash. In addition, two plats received 150 pounds of nitrate of soda per acre. One plat of each of the two treatments was irrigated for several seasons. The soil was a fairly rich moist loam.

The total fruit for the period on the plats receiving phosphorus and potash was about 1589 pounds; while the plat receiving nitrate in addition yielded about 2,215 pounds, or an increase due to nitrogen of 626 pounds of fruit. Under irrigation, nitrate gave much larger increases than without irrigation. In fact, an average of five crops showed a substantial gain on the irrigated nitrate plats, and an actual decrease on the nitrate non-irrigated plats. This would suggest that in some cases water, perhaps, is more important than nitrogen.

EXPERIMENT IN THE O'NEIL ORCHARD

The O'Neil cherry orchard (of the present experiment) consists of a block of 528 trees 18 by 18 feet. Each plat fertilized, or otherwise treated, contains one row of 24 trees. Eight of these trees in each row were two years old, seven were five years old, and nine were six years old in 1913 when the experiment began. Of the 24 trees in each plat, the 16 older trees are averaged in the records The other eight trees have not borne a significant crop, and as some of these trees are of the Morella variety, they are not at present averaged in the results.

The orchard adjoins the Experiment Station farm at Geneva and is on a very stony, somewhat sandy loam soil. The soil is classified as Ontario loam in the United States Bureau of Soils Survey of Ontario County, but is by no means typical Ontario loam being much more stony and lighter in texture. The soil is quite uniform, and the orchard level and well drained. The elevation is some 500 to 520 feet. An analysis of the soil is given in Table 16.

TABLE 16.— ANALYSIS OF SOIL IN O'NEIL CHERRY ORCHARD.
Average of check plats, 1913.

CONSTITUENTS	0-7 INCHES		7-14 INCHES
	Per cent	Pounds per acre 7 inches	Per cent
Nitrogen	0.19	3,800	0.11
Phosphorus	0.059	1,180	0.059
Potassium	1.60	32,000	1.46
Calcium	0.79	15,800	1.29
Magnesium	0.58	11,600	0.95
$CaCO_3$ from CO_2	0.68	13,600	2.86
Total carbon	1.83	36,000	1.30

This soil compares favorably with our type soil. It is somewhat higher in nitrogen, calcium, magnesium, carbon, and carbonates, and somewhat lower in phosphorus.

The orchard has been tilled practically thruout the experiment. The only cover crop used has been weeds which have come up in the fall. It had received no fertilizer previous to the beginning of the experiment. The same general plan of treatment has been followed with the exception that no lime plat has been included as this soil is well supplied with carbonates.

TABLE 17.— YIELD OF CHERRIES IN THE O'NEIL ORCHARD.
Pounds per plat and per tree, 1913 to 1919.

PLAT NO.	TREATMENT	YEARS[a]					TOTAL YIELD, 1913-19	AVERAGE PER TREE, 1913-19	INCREASE OR DECREASE PER TREE OVER NEAREST CHECK
		1914	1915	1916	1917	1918			
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	N-P-K	136.5	454.5	234.0	285.0	699.0	1809.0	113.0	+1.4
2	Nothing	133.5	496.5	253.5	312.0	590.0	1785.5	111.6	....
3[b]	N-P-K	168.0	543.0	211.5	348.0	716.0	1986.5	132.4	+20.8
4	N-P-O	142.5	378.0	157.5	346.5	670.0	1694.5	105.9	+19.4
5	Nothing	73.5	397.5	102.0	286.5	525.0	1384.5	86.5	....
6	N-O-O	114.0	454.5	165.0	271.5	586.0	1591.0	99.4	+12.9
7	N-P-K	108.0	420.0	102.0	213.0	542.0	1385.0	86.6	—6.6
8	Nothing	121.5	526.5	88.5	208.5	546.0	1491.0	93.2	....
9	O-P-K	156.0	526.5	156.0	177.0	549.0	1564.5	97.8	+4.6
10	O-P-K	124.5	439.5	151.5	166.5	684.0	1566.0	97.9	+6.7
11[c]	Nothing	73.5	382.5	103.5	160.5	579.0	1299.0	81.2	....

[a] There was no crop on this orchard in 1913 and 1919.
[b] One tree missing so only 15 trees are averaged.
[c] Plat 11 is an outside row in the orchard.

Fertilizers have, in general, increased the yield of cherries. This is especially true of nitrogen. Phosphorus in the forms of basic slag and raw rock phosphate has apparently been superior to that in the form of acid phosphate. These differences, however, when calculated to increase per year are too small to be very significant.

From the practical standpoint it might be well to consider Plat 3, the complete fertilizer plat, which gave the largest increase over the check. The fertilizer on this plat cost $9.70 per year with nitrate of soda at $75.00, acid phosphate at $25.00, and muriate of potash at $120.00 per ton. In addition it cost at least 65 cents to mix and apply this fertilizer, making the cost of plat treatment $10.35. Calculating this increased crop at 25 pounds of fruit per tree for the seven years, 1913 to 1919, and using 16 trees per plat as an average, we have 400 pounds increase in seven years, or about 60 pounds per year. With cherries at 10 cents per pound, this gives $6.00 as the value of the increase, compared with $10.35 as the cost of producing this increase. Fertilization up to the present time has been unprofitable on this cherry orchard.

TABLE 18.— INCREASE IN TRUNK DIAMETER, O'NEIL CHERRY ORCHARD, 1913–19.

Plat No.	Treatment	Sixteen older trees: Average midtrunk diameter, 1913	Sixteen older trees: Average midtrunk diameter, 1919	Sixteen older trees: Increase 1913–19	Sixteen older trees: Increase over nearest check	Eight younger trees: Average diameter, 1913	Eight younger trees: Average diameter, 1919	Eight younger trees: Increase, 1913–19	Eight younger trees: Increase or decrease over nearest check
		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1	N[illegible]	2.64	5.63	2.99	+0.37	1.09	3.[illegible]	2.22	+0.10
2	N[illegible]	2.81	5.43	2.62	......	1.10	3.22	2.12	......
3a	N[illegible]	2.80	5.87	3.07	+0.45	1.00	3.07	2.07	—0.05
4	N[illegible]	2.74	5.87	3.13	+0.46	0.93	2.84	1.91	—0.16
5	N[illegible]	2.68	5.35	2.67		1.00	3.07	2.07	......
6	N[illegible]	2.68	5.50	2.82	+0.15	1.07	2.95	1.88	—0.19
7	C[illegible]	2.73	5.57	2.84	+0.13	0.98	3.29	2.31	+0.17
8	N[illegible]	2.79	5.50	2.71	......	1.03	3.17	2.14	......
9	C[illegible]	2.84	5.58	2.74	+0.03	1.02	3.33	2.31	+0.17
10	C[illegible]	2.69	5.48	2.79	[a]—0.34	0.98	3.38	2.40	+0.24
11	N[illegible]	2.53	5.66	3.[illegible]	......	1.00	3.16	2.16	......

[a] Fifteen trees averaged.

Plat 11 is an outside row in the orchard, so that it might be better to compare Plat 10 with Plat 8 as a check rather than with Plat 11. This gives Plat 10 an increase in diameter over the check of 0.08 inches instead of a decrease of 0.34 inches. Using Plat 8 as a check

on Plat 10, there has been, in the case of the 16 older trees, an increase in mid-trunk diameter on every plat due to fertilizers. This has not been true of the young trees where, apparently, nitrogen has decreased growth, while phosphorus and potash have increased growth.

EXPERIMENT WITH PEARS

From Table 2 it will be seen that the pear is apparently not so exhaustive of soil fertility as the apple or peach, using less of the principal constituents after coming into bearing. One might suppose that the pear would not respond to fertilizers as readily as the other two fruits, but there have been almost no organized experiments on this point.

Halstead (1904) of the New Jersey Station reports a small fertilizer experiment with pears in which five varieties of standard trees were fertilized as follows: (1) No treatment; (2) 500 pounds per acre of a mixture of equal parts bone meal, acid phosphate, and muriate of potash; and (3) the same as (2) with the addition of 150 pounds of nitrate of soda per acre.

Based on an average for four crops it was found that the weight of fruit was greatest on the phosphorus and potash plat, second on the check plat, and lowest on the complete fertilizer plat. The average weight of individual fruits was largest on the complete fertilizer plat and smallest on the check plat.

EXPERIMENT IN THE HOWARD ORCHARD

The pear orchard used in the present experiment is known as the Howard orchard, and consists of a block of 504 trees taken from a slightly larger block. There are 21 rows of 24 trees each, set 20 by 20 feet. The variety is Kieffer, and the trees were two-year stock set in the spring of 1912. The orchard is located about a mile from Kinderhook, Columbia County, and about 3½ miles from the Hudson River. The slope is slightly to the southeast and the elevation is some 270 feet.

The soil in the orchard is typical of a large area in this locality. It is a fine sand to sandy loam of considerable depth, with a sand and gravel subsoil. The composition of the soil is given in Table 19.

TABLE 19.— COMPOSITION OF SOIL IN THE HOWARD PEAR ORCHARD.

CONSTITUENTS	0-7 INCHES		7-14 INCHES
	Per cent	Pounds in acre 7 inches	Per cent
Nitrogen	0.077	1,540	0.033
Phosphorus	0.086	1,720	0.071
Potassium	1.45	29,000	1.67
Calcium	0.20	4,000	0.21
Magnesium	0.58	11,800	0.68
CO_2 calculated to $CaCO_3$	0.076	1,520	0.043
Total carbon	0.81	16,200	......

The analysis shows that, compared with the type soil, this soil is low in nitrogen, well supplied with phosphorus, low in calcium, fairly high in magnesium, quite low in carbonates, and very low in organic matter. It would indicate that this soil should respond to manure and green manure crops, to nitrogen, and possibly to lime.

The only fertilizer these trees had received previous to 1912 when the work began, was two forkfulls of manure per tree at setting. The orchard has been under cultivation thruout the experiment. Rye, rye and vetch, and rape have been used as covers. In 1915 beans were used as an intercrop and in 1916 silage corn.

The effect of nitrogen and phosphorus could be plainly seen on the beans. Lime showed no visible effect. The nitrogen fertilization was begun in 1914.

Unfortunately, thru a mistake in 1916, and due to an embargo on freight in 1918, no fertilizers were applied in these years; so that considering the additional fact that war conditions prevented potash fertilization in 1917, the results on this orchard are certainly not as significant as they might otherwise be. There has been no crop worth recording up to date. The general fertilizer plan has been used with the exception that there is no plat receiving nitrogen alone.

The results given in Table 20 are so erratic that no very definite conclusions can be drawn. Fertilizers certainly have not affected the diameter growth. Perhaps the next five years' results will give data for more definite conclusions.

TABLE 20.— INCREASE IN MID-TRUNK DIAMETER, HOWARD PEAR ORCHARD, 1913–1919.

PLAT NO.	TREATMENT	YEAR 1913	YEAR 1919	INCREASE, 1913–19	INCREASE OR DECREASE OVER NEAREST CHECK
		Inches	*Inches*	*Inches*	*Inches*
1	N-P-K	0.91	2.60	1.69	—0.10
2	Nothing	0.91	2.70	1.79	......
3	N-P-K	0.93	2.40	1.47	—0.32
4	N-P-O	0.90	2.70	1.80	+0.14
5	Nothing	0.94	2.60	1.66	......
6	O-P-K	0.92	2.40	1.48	—0.18
7	O-P-K	0.90	2.50	1.60	+0.08
8	Nothing	0.88	2.40	1.52	......
9	O-P-K	0.93	2.40	1.47	—0.05
10	$CaCO_3$-P	0.91	2.50	1.59	+0.07

PEACHES

In 1912 there was an experiment begun on the fertilization of peaches on the farm of T. H. King near Trumansburg. The orchard was one of Iron Mountain peaches on a rather heavy clay soil. The trees at the beginning were already somewhat advanced in age. Unfortunately, in 1914 disease, both yellows and little peach, appeared and rapidly grew worse, so that a large number of trees had to be removed. In 1916 one-half the orchard was removed. This condition so obviously affected any results that might be obtained that the experiment was abandoned and no other experiment with peaches was undertaken.

EXPERIMENT WITH APPLE NURSERY STOCK

Western New York is the home of a considerable nursery business of which Geneva is one of the main centers. The growing of nursery stock presents some peculiar problems. Young trees are somewhat exacting in their requirements. From 5,000 to 10,000 trees are usually grown on an acre of land so that the nursery business consists of growing trees in a very intensive way. The soil must be fertile, well drained, and well supplied with organic matter. The opinion prevails that nursery stock makes particularly heavy demands on

fertility, so that it is not commonly grown on the same land year after year. This view is quite reasonable when it is considered that there are a large number of individuals per acre which must make salable trees in one or two years; and that they are then completely removed from the soil, both roots and tops.

Roberts (1895) at the Cornell Station determined the amount of fertilizing constituents removed by an acre of different kinds of nursery stock. He found that, on a basis of 8,000 trees per acre, the apple removed annually, 29 pounds of nitrogen, 10 pounds phosphoric acid, and about 20 pounds of potash per acre. This was more than was removed by either pears, peaches, or plums. (See Table 2.)

EXPERIMENT IN THE SMITH NURSERY

The experiment here described was planned to show the effect of fertilizers in hastening the growth of apple nursery stock, and is confined to records of diameters taken at the end of the experiment. The work began in the spring of 1912, and was ended in the fall of 1914.

The nursery was located on the land of the Smith Nursery Company near Geneva, on a tile-drained clay loam of the Ontario series. The elevation is some 700 feet. An analysis of the soil is given in Table 21.

TABLE 21.— ANALYSIS OF SOIL FROM APPLE NURSERY.

CONSTITUENTS	0–7 INCHES		7–14 INCHES
	Per cent	Pounds in acre 7 inches	Per cent
Nitrogen	0.184	3,680	0.103
Phosphorus	0.059	1,180	0.056
Potassium	1.52	30,400	1.58
Calcium	0.62	12,400	0.61
Magnesium	0.29	5,800	0.37
CO_2 to $CaCO_3$	0.278	5,560	0.088
Total carbon	1.85	37,000	......

The soil is a fertile one, being higher than our average in nitrogen, calcium, organic matter, and carbonates.

PLAN OF NURSERY EXPERIMENT

The following is the plan of treatments. Each plat was 7 by 200 feet and consisted of two nursery rows of trees, separated in all cases by one discard row of trees. The series consisted of 11 plats and was separated by a discard space of 20 feet from a duplicate series of 11 plats in which the treatments were in reverse order, that is, in one series they ran from Plats 1 to 11, and in the other from Plats 11 to 1, so that Plat 1 in one series was opposite (end to end) Plat 11 in the other series. This made the check plats in the two series continuous, except for the 20-foot discard space separating the two series. The arrangement of the plats and the plan of treatment is shown in Fig. 5.

No. of plat	
1.	1,000 pounds acid phosphate.*
2.	No treatment.
3.	2,000 pounds rock phosphate.
4.	4,000 pounds rock phosphate.
5.	16 tons manure.
6.	No treatment.
7.	2,000 pounds rock phosphate and 16 tons manure.
8.	2,000 pounds rock phosphate and 500 pounds muriate potash.
9.	500 pounds muriate of potash.
10.	No treatment.
11.	4,000 pounds rock phosphate and 2 tons limestone.

* Pounds per acre.

FIG. 5.— PLAN OF TREATMENT IN APPLE NURSERY EXPERIMENT.

One-half of each series crosswise of the plats was given, in addition, 300 pounds nitrate of soda per acre applied two years, namely, in the spring of 1913 and 1914. The treatments above outlined were made only once, in 1912, at the beginning of the experiment. There were 35 rows in the experimental block comprising

the following varieties: Rows 1 to 20, Baldwin; Rows 21 to 28, McIntosh; and Rows 29 to 35, Oldenburg.

This means that in Series 1, Plats 1 and 2 were Oldenburg, Plats 3, 4, and 5 were McIntosh; and Plats 6 to 11 were Baldwin. In Series 2, Plats 1 to 6 were Baldwin; Plats 7, 8, and 9 were McIntosh; and Plats 10 and 11 were Oldenburg.

In the fall of 1914, all the trees in the experiment were calipered and averages taken.

Like all cooperative experiments, there is an unfortunate circumstance to be recorded in connection with this experiment. Before the trees could be calipered some of the workmen in the nursery pulled two rows of stock thru both series. These two rows happened to be Plat 6, a check plat, in both series, so that we have only the two checks, Plats 2 and 10, with which to make our comparisons.

The number of trees calipered in each plat varied from 168 to 424. There were 3326 trees calipered on Series 2, and 3295 on Series 1. The measurements are given in Table 22.

The Baldwins have apparently made larger trees in both series than either the McIntosh or Oldenburgs. It seems most logical therefore, to compare the Baldwins with the Baldwin check, and the other two varieties with the Oldenburg check in each series.

The Baldwin checks in the two series vary by 0.6, and the Oldenburg checks by 0.4, or a maximum variation of 0.6; so that 0.6, or less, would scarcely be a significant difference in the experiment. Regarding any difference greater than 0.6 as significant, it will be noted that the only positive effect from fertilizers has been obtained on Plats 7, 8, 9, and 11. On Plats 7 and 8, the rock phosphate and manure and the rock phosphate and potash combinations have increased the growth of both McIntosh and Baldwin. On Plat 9 potash alone has increased growth in McIntosh but not in Baldwin. Nitrate of soda has in no case given an increase equal to the significant difference of 0.6; so that it must be concluded that nitrogen, either as nitrate of soda or in manure, has not increased the growth of these nursery trees. It should be remembered that these trees were on good soil, and received first class cultivation.

TABLE 22.—AVERAGE DIAMETERS IN ONE-THIRTY-SECOND INCHES, NURSERY EXPERIMENT.

PLAT NO.	TREATMENT	VARIETY		AVERAGE OF ALL TREES		AVERAGE OF $NaNO_3$ TREES		AVERAGE OF NO $NaNO_3$ TREES		INCREASE OR DECREASE OVER CHECK		INCREASE OR DECREASE DUE TO NITRATE	
		Series 1	Series 2	Series 1	Series 2	Series 1	Series 2	Series 1	Series 2	Series 1	Series 2	Series 1	Series 2
1	1,000 pounds acid phosphate	Oldenburg	Baldwin	16.3	19.2	16.1	18.9	16.4	19.4	+0.6	+0.1	—0.3	—0.5
2	Check	Oldenburg	Baldwin	15.7	19.1	15.6	19.1	15.7	19.1	......	......	—0.1	0.0
3	2,000 pounds rock phosphate	McIntosh	Baldwin	15.8	17.9	15.9	18.1	15.7	17.7	+0.1	—1.2	+0.2	+0.4
4	4,000 pounds rock phosphate	McIntosh	Baldwin	15.2	19.6	15.2	19.7	15.1	19.4	—0.5	+0.5	+0.1	+0.3
5	16 tons manure	McIntosh	Baldwin	16.2	18.5	16.3	18.3	16.0	18.7	+0.5	—0.6	+0.3	—0.4
6	Check	Baldwin	Baldwin	......	......	......	......	......	......	......	......	......	......
7	2,000 pounds rock phosphate, 16 tons manure	Baldwin	McIntosh	20.4	17.1	19.8	17.3	21.0	16.9	+1.9	+1.8	—1.2	+0.4
8	2,000 pounds rock phosphate, 500 pounds KCl	Baldwin	McIntosh	20.2	16.5	20.3	16.7	20.0	16.2	+1.7	+1.2	+0.3	+0.5
9	500 pounds KCl	Baldwin	McIntosh	18.8	16.6	18.8	16.4	18.8	16.7	+0.3	+1.3	0.0	—0.3
10	Check	Baldwin	Oldenburg	18.5	15.3	18.1	15.4	18.8	15.2	......	......	—0.7	+0.2
11	4,000 pounds rock phosphate, 4,000 pounds $CaCO_3$	Baldwin	Oldenburg	18.3	16.5	18.1	16.7	18.5	16.2	—0.2	+1.2	—0.4	+0.5

VINEYARD EXPERIMENT

In 1914, Hedrick and Gladwin of this Station reported the results of a fertilizer experiment with grapes in Chautauqua County. It was found that, altho yields generally had declined in the grape belt, lowered fertility was probably only one of the causes. The experiment proper was carried out on one of the better grape soils. Where similar experiments were conducted on a variety of grape soils, the results proved erratic and unsatisfactory. The main experiment was planned to show the effect of nitrogen, phosphorus, and potassium, alone and in combination, on vigor, growth, yield, character of fruit, and maturity, using the common fertilizers, nitrate of soda, cottonseed meal, acid phosphate, and soluble potassium salts. It was found that nitrogen had a marked beneficial effect on yield, quality of fruit, and growth. Lime had no effect, while phosphorus and potassium were not profitable.

As the grape industry developed in past years, it was extended to the poorer soil types on the higher elevations. Many of the vineyards on these poorer soils present quite a problem. The soil is generally poorly drained, much of it quite stony, the surface soil shallow, and, in many cases, the shale comes quite close to the surface. These factors make many vineyards on these soils unprofitable in comparison with those on the better soils. The general character of these soils is so obviously the important factor in the poorer vineyards, that it was thought that perhaps the production of grapes might be made more profitable if systematic methods of soil improvement were adopted at the time or before the vineyard was set out, combined with good treatment afterward. With this purpose in view, a piece of as uniform land as possible was selected on Dunkirk shale loam soil about 1½ to 2 miles southwest of Fredonia in Chautauqua County. The slope is slightly to the north, and is adjoined on the south by land of more abrupt slope. The elevation is close to 900 feet. Since drainage was poor, the area was first tile drained in the early spring of 1912, the laterals running north and south about fifty feet apart. A bad feature of the location is the presence of the higher land to the south. In this soil the shale is near the surface, so that in times of heavy rain it is somewhat difficult to divert the surface water away from the young vineyard. In fact, in 1916 and 1917, the water above washed out and overflowed its

outlet and gullied the end of the vineyard crosswise of the plats so that the yields had to be corrected for this factor.

After draining, the land was plowed in 1912, one-half of it about 12 inches deep with a deep-tillage machine crosswise of the plats, and the other half to the ordinary 7-inch depth.

The soil in this piece was analysed in 1912 and the results are given in Table 23.

TABLE 23.— ANALYSIS OF SOIL FROM VINEYARD.

CONSTITUENT	0-7 INCHES		7-14 INCHES
	Per cent	Pounds in acre 7 inches	Per cent
Nitrogen	0.23	4,600	0.16
Phosphorus	0.057	1,140	0.041
Potassium	1.88	37,600	2.20
Calcium	0.17	3,400	0.15
Magnesium	0.41	8,200	0.59
CO_2 as $CaCO_3$	0.095	1,900	0.061
Total carbon	1.99	39,800	....

Contrary to what might be expected, this soil is well supplied with nitrogen, potassium, and organic matter, is somewhat low in phosphorus, and is quite low in calcium and carbonates. Probably the poor character of the soil is due more to physical causes such as drainage, shallowness, rock content, and combination of plant-food constituents, than to actual low content of total food elements.

PLAN OF VINEYARD EXPERIMENT

The plats in this experiment were arranged as follows: Each plat consists of two rows of vines 8½ feet apart and 8 feet in the row. These rows are 320 feet long, so that each contains 40 vines, or 80 vines per plat. Each plat is separated from the adjacent ones by a discard row of vines. There are in all 18 plats, consisting of 9 treatments in duplicate series. The arrangement and treatment of the plats is shown in Fig. 6.

The phosphorus and limestone treatment was to be made every two years. The phosphates were applied in the summer of 1912,

one-half of each before, and one-half after plowing. The land was plowed in August 1912, and rye was sown in September. In the spring of 1913 the limestone was applied, and the land again plowed in the same way as in 1912.

No. of plat	
1.	2,000 pounds rock phosphate.*
2.	4,000 pounds rock phosphate.*
3.	Check.
4.	Complete fertilizer annually after setting: 200 pounds acid phosphate, 250 pounds nitrate of soda, and 50 pounds muriate of potash.
5.	2,000 pounds acid phosphate.
6.	2,000 pounds acid phosphate and 4 tons limestone.
7.	Check.
8.	4,000 pounds rock phosphate and 4 tons limestone.
9.	4 tons limestone.

* Pounds per acre.

FIG. 6.—PLAN OF TREATMENT IN VINEYARD EXPERIMENT.

The rye in 1913 made a good growth except on the check plats. This crop seemed to respond in a marked way to both rock phosphate and acid phosphate, seemingly as well to the one as to the other.

The roots were set in 1913 after which the whole vineyard received an application of two tons of ground limestone per acre, except one-half of each check plat.

This vineyard has been well cared for, cultivated each year, and a cover crop sown in late summer. Rye, barley, barley and vetch, and red clover have been used. In the spring of 1914 and 1915, about 150 pounds per acre of nitrate of soda was used around the vines to hasten growth at the start.

In 1914, when the vineyard was plowed, a marked difference was again noted in the cover crop. Vetch was used this year, and was exceedingly poor on the check plats. The growth on the plats receiving phosphorus in either form was very good. The vineyard was posted and wired in the fall of 1914. Each spring the same

TABLE 24.— YIELD OF GRAPES ON THE EXPERIMENTAL VINEYARD, 1915 TO 1919.
Pounds of grapes per plat.

PLAT NO.	TREATMENT	YEAR					TOTAL, 1915–19	AVERAGE, PER PLAT PER YEAR	INCREASE OR DECREASE OVER NEAREST CHECK	INCREASE OR DECREASE USING PRO-GRESSIVE CHECKS [b]
		1915	1916	1917	1918	1919 [a]				
	SERIES 1									
1	2,000 pounds rock phosphate.	53	266	462	107	354	1,242	248	+22	+22
2	4,000 pounds rock phosphate..	37	153	392	81	384	1,047	209	—17	—17
3	Check.....................	90	200	406	103	332	1,131	226	....	....
4	Complete fertilizer...........	64	288	490	122	418	1,382	276	+50	+52
5	2,000 pounds acid phosphate .	38	170	372	121	383	1,084	217	— 6	— 6
6	2,0[illegible], 8,000 pounds limestone.....	52	221	448	97	442	1,260	252	+32	+31
7	Check.....	61	200	392	124	325	1,102	220	....	....
8	4,000 pounds rock phosphate, 8,000 pounds limestone.....	80	260	392	113	471	1,316	263	+43	+33
9	8,000 pounds limestone.......	145	360	406	126	362	1,399	280	+60	+40
	SERIES 2									
1	2,000 pounds rock phosphate..	81	283	426	96	459	1,345	269	— 2	+19
2	4,000 pounds rock phosphate..	54	247	308	107	341	1,057	211	—60	—49
3	Check.....................	134	300	392	152	375	1,353	271	....	....
4	Complete fertilizer...........	163	456	602	176	573	1,970	394	+123	+80
5	2,000 pounds acid phosphate..	97	417	630	228	550	1,922	384	+27	+27
6	2,000 pounds acid phosphate, 8,000 pounds limestone.....	56	327	552	175	519	1,629	326	—117	—74
7	Check.....................	121	464	798	222	609	2,214	443	....	....
8	4,000 pounds rock phosphate, 8,000 pounds limestone.....	98	429	734	187	537	1,985	397	—46	—46
9	8,000 pounds limestone.......	95	349	476	103	282	1,305	261	—182	—182

[a] Yield of six vines in each row discarded due to washing.
[b] Here the increase between checks is considered progressive, and the same also as between check Plat 7 in Series 1 and check Plat 3 in Series 2.

difference in the cover crop could be noticed distinctly. In 1916 rye was used, and the difference was so marked that Plats 2 and 3 were left until maturity and harvested. Plat 2, receiving 4000 pounds rock phosphate per acre, gave 340 pounds of cured rye; and Plat 3, a check, gave 112 pounds.

In the severe winter of 1917 to 1918 the vineyard suffered some winter injury, Plat 9 in Series 2 suffering more than the others.

The vineyard began bearing in 1915, and has borne each year. From 1918 on, the wood removed in pruning has been weighed.

In Series 1, Plats 1 and 2 are inconsistent, the larger quantity of rock phosphate giving a lower yield than half the quantity, and also lower than the check. Neither are Plats 5 and 6 consistent, as it would not be expected that acid phosphate and limestone would give such an increase over acid phosphate alone, especially since the acid phosphate plat had also received two tons of limestone per acre. The same is true of Plats 2 and 8 as here again limestone would hardly be expected to greatly increase the yield, since Plat 2 also received two tons of limestone after the vineyard was set.

In Series 2, Plat 2 has again given a much lower yield than Plat 1, and a much lower yield than the check. The complete fertilizer plat in both series has given a considerable increase in yield using any method of comparison. This series reverses some of the results of Series 1, as for instance, in Plats 5 and 6, and 8 and 9, the sign of the increase is just reversed. In Series 2, Plat 7, a check plat, is by far the highest yielding plat in the vineyard. With the exception of the complete fertilizer, it must be concluded that some other factors besides the fertilizers used have been responsible for the variations in yield. The fact that in both series complete fertilizer has increased the yield materially is an indication that possibly available nitrogen is an important factor in this vineyard. With this in view, a new plan of treatment has been made for one series of plats which will introduce the factor of available nitrogen. At the same time, it has also been planned to show the effect of manure and potash. The other series will be left under the original plan of treatment.

In Series 1, the checks and Plat 9 have produced the least wood. As in the yields of fruit, Plat 2 in both series is lower than Plat 1. In Series 2, Plat 7, a check, is also high in production of wood. The acid phosphate plats are also high.

TABLE 25.— WEIGHT OF WOOD REMOVED IN 1918 AND 1919 IN POUNDS PER ACRE.

PLAT NO.	TREATMENT	SERIES 1		SERIES 2	
		1918	1919	1918	1919
		Pounds	*Pounds*	*Pounds*	*Pounds*
1	2,000 pounds rock phosphate........	115	lost	110	105
2	4,000 pounds rock phosphate........	104	lost	93	82
3	Check...........................	100	75	90	78
4	Complete fertilizer.................	122	98	117	115
5	2,000 pounds acid phosphate.........	105	113	133	118
6	2,000 pounds acid phosphate, 8,000 pounds limestone.................	105	101	138	109
7	Check...........................	87	67	130	129
8	4,000 pounds rock phosphate, 8,000 pounds limestone.................	113	77	118	125
9	8,000 pounds limestone.............	74	65	59	72

It must be remembered that this vineyard is young, and has now well established the bearing habit, so that the next five years may show different results from those secured the last five years.

GENERAL CONCLUSIONS

In drawing general conclusions it must be said that, with regard to positive results, the experiments have to date been disappointing. Evidently, other factors have been operative which have outweighed and masked any results of a positive nature which may have been due to the fertilizers applied. The writer feels that the tree individuality factor together with the small populations which had to be used were not the least important in contributing to the results. Many trees which have not received good care, orchards on poor soils, and those which have to compete with other crops for plant food undoubtedly respond to additions of available plant food as shown by experiments elsewhere. The orchards used in these expermenta are evidently not in this class, and many years of fruit production might be necessary before lack of available plant food would lessen this production.

LITERATURE CITED

Alderman, W. H.
1915 The fertilization of peach orchards. *W. Va. Agr. Exp. Sta. Bul. 150.*
1916 Orchard fertilization tests. *Trans. Ind. Hort. Soc. 1916, 40–56.*

Ballou, F. H.
1912 The rejuvenation of orchards. *Ohio Agr. Exp. Sta. Bul. 240.*

Blake, M. A.
1909 The first season with the peach orchard. *N. J. Agr. Exp. Sta. Bul. 219.*

——— and Farley, A. J.
1910 Fertilizer experiments with cherries. *N. J. Agr. Exp. Sta. Rpt. 1909, 95–96.*
1912 Fertilizer experiments with apples. *N. J. Agr. Exp. Sta. Rpt. 1911, 75–82.*

Brooks, W. P.
1910 Manuring an apple orchard. *Mass. Agr. Exp. Sta. Rpt. 1909, 10–20.*

Carmody, P. J.
1912 Lime for orchards. *Jour. Dept. Agr. Victoria,* 10, *640–641.*

Dayton, S. C. and Voorhees, S. S.
1895 Field experiments with fertilizers upon peach trees. *N. J. Agr. Exp. Sta. Rpt. 1894, 121–127.*

Garcia, F.
1917 Report of the Horticultural Department. *N. Mex. Agr. Exp. Sta. Rpt. 1915–1916, 29–30.*

Gourley, J. H.
1914 The effects of fertilizers in a cultivated orchard. *N. H. Agr. Exp. Sta. Bul. 168.*

Halsted, B. D.
1904 Report of the Horticulturist. *N. J. Agr. Exp. Sta. Rpt. 1903, 334, 336.*

Hedrick, U. P.
1907 The effect of wood ashes and acid phosphate on the yield and color of apples. *N. Y. Agr. Exp. Sta. Bul. 289.*
1911 Is it necessary to fertilize an apple orchard? *N. Y. Agr. Exp. Sta. Bul. 339.*

——— and Gladwin, F. E.
1914 A test of commercial fertilizers for grapes. *N. Y. Agr. Exp. Sta. Bul. 381.*

Holladay, A. L.
1893 Fertilizer tests on grapes. *Va. Agr. Exp. Sta. Bul. 35.*

Jenkins, E. H.
1905 Observations on the fertilization of peach orchards. *Conn. State Agr. Exp. Sta. Rpt. 1904, 444–447.*

Maze, P.
1916 In Percival's Agricultural Botany, page 172. *Agricultural Botany, John Percival, New York: Henry Holt & Co. 1916.*

Neale, A. T.
1891 Soil and crop tests. *Del. Agr. Exp. Sta. Bul. 11, 8–9, 14.*
1894 Soil tests with fertilizers used on peach trees. *Del. Agr. Exp. Sta. Rpt. 1893, 13–16.*

Remy, T.
1913 The application of nitrogen in relation to fruit-bud formation. *Mitt. Deut. Landw. Gesell.* **28**, *416–421.* (*Exp. Sta. Record* **29**, *539.*)

Rivière, G. and Bailbache, G.
1914 The influence of chemical fertilizers on the ripening time of pears. *Jour. Soc. Nat. Hort. France* **4**, *ser. 15, June 1914, 435–438.* (*Exp. Sta. Record* **31**, *534.*)

Roberts, I. P.
1895 Soil depletion in respect to the care of fruit trees. *Cornell University Agr. Exp. Sta. Bul. 103.*

Stewart, J. P.
1918 The fertilization of apple orchards. *Pa. Agr. Exp. Sta. Bul. 153.*

Woburn Experimental Fruit Farm Report.
1917 *Sixteenth Report of Woburn Experimental Fruit Farm.*

Waynick, D. D.
1918 A statistical study of nitrification in soils. *Univ. Cal. Pubs. Agr. Sci., 3, 243–270.*

Whitten, J. C.
1917 Nutrition of fruits with special reference to hardiness. *Mo. Agr. Exp. Sta. Bul. 151, 47.*

——— and Wiggans, C. C.
1915 Orchard nutrition. *Mo. Agr. Exp. Sta. Bul. 131, 482–483.*
1916 Orchard nutrition. *Mo. Agr. Exp. Sta. Bul. 141, 32.*
1917 Nutrition of fruits with special reference to their hardiness and resistance to disease. *Mo. Agr. Exp. Sta. Bul. 147, 40–42.*

Woods, C. D.
1918 Fertilizer experiments on apple trees at Highmoor Farm. *Me. Agr. Exp. Sta. Bul. 269, 9–10.*

SOURCES OF AGRICULTURAL LIMING MATERIALS *

R. C. COLLISON

INTRODUCTION

A number of factors are in operation today which make the agricultural lime situation somewhat different from that of several years ago. Prices have advanced and transportation charges have increased, while inefficient transportation service renders it difficult for the farmer to secure adequate supplies of necessities. At the same time, the recognition of the need of many soils for basic material is more pronounced so that the whole subject of lime and liming has never been so important. The change in the economic situation makes it more essential than ever that the farmer should be able to secure liming material quickly and at the lowest cost possible. This year many companies producing liming materials will be forced to cancel orders because they will be unable to ship their product. This probably means many farmers will not use lime this year, and if the situation does not improve production will be decreased on those soils which require the addition of lime for the best results.

In the light of these conditions, it was thought desirable to furnish as complete a list as possible of producers of liming materials serving the farmers of the State. Many times, if several sources are available, one can secure liming material more economically by knowing these sources and calculating comparative values.

NECESSITY OF LIME

The necessity of lime on many soils of the State is generally recognized. Unfortunately, in those sections where it is needed most, there are either no supplies or very inadequate supplies of lime. The economic maintenance of soil fertility depends on the

* Reprint of Bulletin No. 478, June, 1920. For a more detailed and complete discussion of the subject of ground limestone and its agricultural use see Bulletins Nos. 400 and 430 of this Station.

production of legumes and good crops generally. Many of our most valuable legumes require a large available supply of calcium and a soil of alkaline reaction.

At least 50 to 75 per cent of our soils would be distinctly benefitted by the addition of suitable basic material. It has been satisfactorily demonstrated that a large majority of the soils of the southern half of the State would yield good crops of clover and alfalfa if the necessary conditions were met, conditions which include drainage and lime. Liming material on most of these soils is absolutely essential to the production of these crops.

THE KIND OF LIMING MATERIAL TO USE

There has been much discussion of the comparative merits of various forms of basic material for soils. In general, the matter can be summed up in the single statement: Use the form which is most economical under local conditions. Whether this will be burned lime, hydrated lime, ground limestone, or lime by-products will depend on the following conditions: (1) grade of material as shown by the total available neutralizing ingredients per ton and expressed by the so-called calcium carbonate equivalent, (2) first cost of material, (3) transportation charges per ton, (4) ease of handling, and (5) distance material has to be moved to farm.

When all five points are considered, a good grade of ground limestone (one having a calcium carbonate equivalent of over 90 per cent) will be found, in the majority of cases, to be most economical. However, there are instances in which, for one reason or another some other form of liming material will be more economical as for example in the case of a long haul, high freight charges, excessive prices, or a poor grade of available supplies.

FINENESS OF MATERIAL

The fineness of the material to be used should depend somewhat on the amount applied. This is particularly true of ground limestone. If a small application of 500 to 1000 pounds per acre is made it may be well to have a finer product than if a heavy application is made such as two tons or more per acre. In the former case, a product practically all of which passes a 40-mesh screen would be preferable, while in the latter case, one passing only a 10-

mesh screen would be fine enough. In general, however, it will be more economical of labor to apply two tons once every three to five year rotation than to supply a small quantity each year.

MAGNESIUM LIMESTONES

On the large majority of soils there is no reason for discriminating against magnesium limestones. Based on its chemical action, 84 pounds of magnesium carbonate will have the same neutralizing effect on soil acidity as 100 pounds of calcium carbonate, so that in this respect magnesium stones are superior to calcium limestones. The maximum percentage of magnesium carbonate found in the common limestones of New York is about 45, so that even in the case of such a "dolomite," there would still be some 50 to 55 per cent of calcium carbonate. There are many good magnesium limestones in the State.[1]

LIMESTONE SCREENINGS AND CRUSHER DUST

Many large companies have a great supply of material as a by-product from the production of crushed stone and frequently this material is of very fair grade and can be obtained cheaply. For example, one company is prepared to furnish such material in bulk car lots at $1.00 per ton. The material usually runs from one-fourth inch pieces down to fine dust and if applied in quantities of two tons or more per acre would be a very good source of lime, providing analysis did not run too low.

BUYING LIMING MATERIAL

In the case of ground limestone, it is usually cheaper to buy in bulk, that is by the car load. If much liming is to be done and if applications of from 1 to 3 tons per acre are to be made, it will be well worth while to buy in car lots. The cost of sacks and of the labor involved in sacking adds greatly to the cost of the material, usually from $2.00 to $4.00 per ton. Ground limestone may be purchased at such a time that it can be hauled directly to the field and applied; or it can be stored, as it keeps indefinitely, altho it should be protected from rain.

[1] Technical Bulletin No. 47 of this Station.

In buying any kind of lime material, what is desired is the greatest amount possible of available calcium per dollar invested.

CALCULATING COMPARATIVE COST OF MATERIALS

The farmer often has several quotations on different products varying in quality, price, freight rates, and hauling distance. It is always desirable to know which of these products would be most economical when all factors are considered but many times this is a difficult matter to determine. In the first place, analyses of material are not uniform; then the producers guarantee and the actual analyses do not always agree; and, again, different lots from the same quarry or kiln may vary considerably. If the actual calcium carbonate equivalent of the material was known, it would be a relatively simple matter to calculate comparative costs laid down in the field.

Table 1 has been prepared to aid in making such calculations. To use this table, it is necessary to know the following: (1) the approximate calcium carbonate equivalent of the material, (2) the original cost of the material per ton, (3) the freight per ton to destination, and (4) the approximate cost of hauling and application.

If two or more samples are being considered on which any of above items are the same, these items can be left out of the calculation. That is, if two products are being compared on which the freight per ton is the same, or on which the first cost per ton, or any other item is the same, this item does not have to be taken into account. Such a calculation will of course, give the comparative ratio of cost only; that is, it will show which of two or more products is the cheaper to buy. If the actual cost per unit of material is desired, all the above items must be taken into consideration.

The sum of the above items make up what may be called the total cost per ton of material. The calculations given in the table are figured for each $1.00 of total cost per ton and on a basis of 100 pounds actual calcium carbonate for percentages of calcium carbonate equivalent ranging from 50 to 180. These percentages cover the ranges of low grade and high grade limestone, magnesium limestone, hydrated, and burnt lime, or any other material in which the total carbonates or carbonate equivalents are known.

CALCIUM CARBONATE EQUIVALENT

By this term is meant the total neutralizing ability of any material expressed in percentage of $CaCO_3$ (calcium carbonate) Analyses

TABLE 1.— DATA FOR CALCULATING COMPARATIVE COSTS OF LIMING MATERIALS HAVING VARIOUS CALCIUM CARBONATE EQUIVALENTS RANGING FROM 50 TO 180 PER CENT.

Cost of 100 pounds $CaCO_3$ per each $1.00 total cost per ton.

$CaCO_3$ Equivalents	Cost of 100 pounds $CaCO_3$	$CaCO_3$ Equivalents	Cost of 100 pounds $CaCO_3$	$CaCO_3$ Equivalents	Cost of 100 pounds $CaCO_3$	$CaCO_3$ Equivalents	Cost of 100 pounds $CaCO_3$
Per Cent	*Cents*	*Per cent*	*Cents*	*Per cent*	*Cents*	*Per cent*	*Cents*
50	10.00	90	5.56	130	3.85	170	2.94
51	9.80	91	5.50	131	3.82	171	2.92
52	9.62	92	5.44	132	3.79	172	2.91
53	9.43	93	5.37	133	3.76	173	2.89
54	9.27	94	5.32	134	3.73	174	2.87
55	9.09	95	5.26	135	3.70	175	2.86
56	8.93	96	5.21	136	3.68	176	2.84
57	8.77	97	5.15	137	3.65	177	2.82
58	8.63	98	5.10	138	3.62	178	2.81
59	8.48	99	5.05	139	3.60	179	2.79
60	8.33	100	5.00	140	3.57	180	2.78
61	8.20	101	4.95	141	3.55		
62	8.07	102	4.90	142	3.52		
63	7.94	103	4.85	143	3.50		
64	7.82	104	4.81	144	3.47		
65	7.69	105	4.76	145	3.45		
66	7.58	106	4.72	146	3.42		
67	7.47	107	4.67	147	3.40		
68	7.36	108	4.63	148	3.38		
69	7.25	109	4.58	149	3.36		
70	7.14	110	4.54	150	3.33		
71	7.04	111	4.50	151	3.31		
72	6.95	112	4.46	152	3.29		
73	6.85	113	4.43	153	3.27		
74	6.76	114	4.39	154	3.25		
75	6.67	115	4.35	155	3.22		
76	6.58	116	4.31	156	3.20		
77	6.49	117	4.28	157	3.18		
78	6.41	118	4.24	158	3.16		
79	6.33	119	4.20	159	3.14		
80	6.25	120	4.16	160	3.12		
81	6.17	121	4.13	161	3.11		
82	6.10	122	4.10	162	3.09		
83	6.03	123	4.07	163	3.07		
84	5.95	124	4.03	164	3.05		
85	5.88	125	4.00	165	3.03		
86	5.82	126	3.97	166	3.01		
87	5.75	127	3.94	167	2.99		
88	5.68	128	3.91	168	2.98		
89	5.62	129	3.88	169	2.96		

differ in method of statement. Many companies handling liming materials will give the calcium carbonate equivalent or other analysis when requested to do so. If such analysis is stated in terms of calcium and magnesium oxides, multiply the percentage of calcium oxide (CaO) by 1.8, and the percentage of magnesium oxide (MgO) by 2.1; then add these two results together, and the sum will be the calcium carbonate equivalent of the sample.

If the analysis is stated in terms of calcium and magnesium carbonates, multiply the percentage of magnesium carbonate by 1.2, and add this to the percentage of calcium carbonate. The sum is the calcium carbonate equivalent.

EXAMPLES

In the table, the first column gives the percentage of calcium carbonate equivalent and the second column the cost of 100 pounds actual calcium carbonate per $1.00 total cost per ton.

Example 1.— It is assumed that two products, both ground limestones, are under consideration. One of these analyzes 85 per cent and the other 95 per cent calcium carbonate equivalent. The former costs $2.50 at the quarry, the freight rate is $2.00 per ton, and it costs $1.50 a ton to haul and apply it to the land. The latter costs $3.00, freight $2.50, and hauling and applying $1.50. This gives the 85 per cent product a total cost of $6.00 per ton, and the 95 per cent product a total cost of $7.00 a ton. Looking up these two analyses in the table, we find that in the case of the 85 per cent grade, 100 pounds $CaCO_3$ cost 5.88 cents, and in the case of the 95 per cent grade, 100 pounds $CaCO_3$ cost 5.26 cents for each $1.00 total cost; or for

$6.00 total cost, 6 x 5.88 cents = 35.3 cents, and for
$7.00 total cost, 7 x 5.26 cents = 36.8 cents.

Therefore, under these particular conditions, the 85 per cent grade would be a little the cheaper. Different conditions, of course, might reverse this.

Example 2.— Again, it is assumed that a burned lime, a hydrated lime, and a ground limestone are under consideration.

The data on the burned lime sample are as follows: CaO, 95.6 per cent; cost per ton, $12.50; freight per ton, $3.00; and hauling and applying $1.50 per ton. The calculation follows:

95.6 per cent CaO x 1.8 = 172.0 per cent $CaCO_3$ equivalent.

$12.50 plus $3.00 plus $1.50 = $17.00 total cost per ton.

From the table, 100 pounds 172 per cent $CaCO_3$ costs 2.91 cents per $1.00 cost per ton.

Therefore, $17.00 total cost x 2.91 = 49.5 cents, cost of the material.

The data on the hydrated lime sample are as follows: CaO, 72.2 per cent; cost per ton, $15.00; freight per ton, $3.00; and hauling and applying $1.00 per ton. The calculation follows:

72.2 per cent CaO x 1.8 = 130 per cent $CaCO_3$ equivalent.

$15.00 plus $3.00 plus $1.00 = $19.00 total cost per ton.

From the table, 100 pounds 130 per cent $CaCO_3$ costs 3.85 cents per $1.00 cost per ton.

Therefore, $19.00 total cost x 3.85 = 73.2 cents, cost of the material.

The data on the ground limestone sample are as follows: CaO, 30.0 per cent; MgO, 20.7 per cent; cost per ton, $3.00; freight per ton, $3.00; and hauling and applying, $1.50 per ton. The calculation follows:

30.0 per cent CaO x 1.8 = 54.0 per cent $CaCO_3$ equivalent.

20.7 per cent MgO x 2.1 = 43.5 per cent $CaCO_3$ equivalent.

54.0 plus 43.5 = 97.5 per cent $CaCO_3$ equivalent (total).

$3.00 plus $3.00 plus $1.50 = $7.50 total cost per ton.

From the table, 100 pounds 97.5 per cent $CaCO_3$ costs 5.12 cents per $1.00 cost per ton.

Therefore, $7.50 total cost x 5.12 = 38.4 cents, cost of material.

In this example, the ground limestone would furnish the cheapest supply of calcium carbonate.

These examples are merely given to show the method of calculating comparative costs, and may not at all represent actual conditions.

PRODUCERS OF LIMING MATERIALS

In compiling the lists of producers who supply the farmers of New York State with liming materials, it was the endeavor to make them as complete as possible; however, undoubtedly a few have been overlooked. The author here wishes to thank the Farm Bureau Agents of the State for their cooperation in helping to bring up to date the lists given in Tables 2 and 3.

TABLE 2.— PRODUCERS OF LIMING MATERIALS IN NEW YORK STATE, BY COUNTIES.

COUNTY	FIRM NAME AND ADDRESS	LOCATION OF QUARRY	KIND OF LIMING MATERIAL PRODUCED	CAPACITY
Albany	1. Callanan Road Imp. Co., South Bethlehem	South Bethlehem	Screenings and	
	2. Stephen Day, Ravena	Coeyman's Hollow	ground limestone	
Allegany	3. Farmer's Lime Co., Burns	Canaseraga		Large
Broome	4. Endicott-Johnson Co., Endicott	Factory at Endicott	Tannery lime	
Cattaraugus	5. Eastern Lime & Fert. Co., Franklinville	Gasport	Ground limestone	Large
Cayuga	6. Cayuga Limestone Co., Union Springs	Union Springs	Ground limestone	
	7. Doud Limestone Co., Red Creek	Victory	Ground limestone	
	8. W. H. Moore, Moravia	Moravia	Ground limestone	
Chautauqua	9. Bone Dry Lime Corp., Cassadaga	Cassadaga	Marl	Small
Chemung	10. J. Langdon Co., Elmira	Pekin	Ground limestone	Large
Chenango	No producers			
Clinton	11. Chazy Marble & Lime Co., Chazy	Chazy	Burnt lime	Large
Columbia	12. B & B Lime & Stone Co., Mellenville	Mellenville	Ground limestone	
	13. N. Y. & New England Cement & Lime Co., Hudson	Hudson	By-product	
Cortland	No producers			
Delaware	No producers			

Dutchess	14. H. S. Carpenter, Stanfordville	Stanfordville	Ground limestone	Small
	15. Kelly Island Lime & Transport Company, Buffalo	Dover Plains	Ground limestone	Large
	16. Glen F[illegible] n St., N. Y. City.	Clove Valley	Ground limestone	Large
	17. Putna[illegible] 103 Park Ave., New York City	Dover Plains	Ground limestone, burnt, and hydrated lime	Large
Erie	18. Kelly Island Lime & Transport Co., Buffalo	Buffalo	Ground limestone	Large
	19. Michigan Limestone Co., Buffalo	Michigan	Ground limestone	Large
	20. Buffalo Cement Co., Buffalo	Buffalo	....	....
Essex	21. N. Y. & Penn. Lime Co., Willsboro	Willsboro	By-product	....
	22. George Notman, Keene Valley	....	Ground limestone	....
Franklin	No producers	....	....	....
Fulton	23. Merl Haines, Mayfield	Mayfield	Burnt lime and by-product	....
	24. Willard Kegg, Cranberry Creek	Cranberry Creek	Burnt lime and by-product	....
Genesee	25. LeRoy Lime Company, LeRoy	LeRoy	Ground limestone	Small
Greene	26. Walter Smith, Catskill	Catskill	Burnt and hydrated lime	Small
	27. W. C. Terry, Catskill	Athens	Ground limestone	Small
Hamilton	No producers	....	....	....
Herkimer	28. Carry Grant, Poland	Poland	Ground limestone	Small
	29. John Harris, Middleville	Middleville	Ground limestone	Small
	30. Newport Stone Co., Newport	Newport	Ground limestone	Small
	31. Henry Brewer, W. Winfield	W. Winfield	Ground limestone	Small
	32. Christopher Sassman, Salisbury Center	S. Center	Ground limestone	Small
	33. Mahardy & Murphy, Middleville	Middleville	Ground limestone	Small

TABLE 2.— PRODUCERS OF LIMING MATERIALS IN NEW YORK STATE, BY COUNTIES (*continued*).

COUNTY	FIRM NAME AND ADDRESS	LOCATION OF QUARRY	KIND OF LIMING MATERIAL PRODUCED	CAPACITY
Jefferson	34. M. E. Lingerfelter, Clayton	Clayton	Ground limestone	Small
	35. Adams & DuFord Co., Chaumont	Chaumont	Ground limestone	Large
	36. Holley Case, Dexter	Limerick	Ground limestone	Large
Kings	No producers			
Lewis	37. Noel Adams, Harrisville	Pitcairn	Ground limestone	Small
Livingston	38. Caledonia Chemical Co., Caledonia	Caledonia	Marl	Large
Madison	39. A. S. Peck. Valley Mills	Valley Mills	Ground limestone	
	40. Worlock s.	Blakeslee	Ground limestone	Large
	41. Conley Stone Co., Utica	Blakeslee	Ground limestone	Large
Monroe	42. Dolomite Products Co. Inc., Rochester	Lincoln Park	Ground limestone	Large
Montgomery	43.	St. Johnsville	Ground limestone	
	44.	Amsterdam	Ground limestone	
	45. lam.	Amsterdam	Button waste	
	46. e.	Canajoharie	Ground limestone	
Nassau	No producers			
New York	See Nos. 16, 93, 94, 101, and 108			
Niagara	47. Pekin Limestone Quarry, Ransomville	Pekin	Ground limestone	Large
	48. Wickwire Limestone Co., Gasport	Gasport	Ground limestone	Large
Oneida	49. F. E. Conley Lime & Fert. Co., Utica	Munns & Blakeslee	Ground limestone	Large
	50. Quentin McAdam, Utica	Deansboro	Ground limestone	
	51. Putnam Quarries, Oriskany Falls	Oriskany Falls	Ground limestone	

	52. W. A. Salisbury, Waterville	Waterville	Ground limestone	....
	53. Sugar River Stone Co., Boonville	Boonville	Ground limestone	....
	54. Gallagher & Cool, Remsen	Remsen	Ground limestone	Small
	55. Trenton Lime Co., Inc., Remsen	Remsen	All forms	Large
Onondaga	56. Rock Cut Stone Co., Syracuse	Rock Cut	Screenings and ground limestone	Large
	57. Solvay Process Co., Syracuse	Jamesville	Ground limestone	Large
Ontario	58. Geneva Limestone Co., Geneva	Oaks Corners	Ground limestone	Large
Orange	59. M. M. Leher, Port Jervis	Port Jervis	Ground limestone	....
	60. M. A. Lain, Westtown	Westtown	Ground limestone	Small
	61. Booth Bros., Goshen	Campbell Hall	Ground limestone	Large
	62. M. V. B. Horton, Warwick	Warwick	Ground limestone	Small
	63. James Bull, Monroe	Monroe	Ground limestone	Small
	64. Harrison & Curtis, Newburg	Newburg	Burnt lime	Large
Orleans	65. Medina Limestone Co., Medina	Medina	Ground limestone	Large
	66. R. J. Cole, Clarendon	Clarendon	Ground limestone	Small
Oswego	No producers	....	....	....
Otsego	67. W. H. Fretz, Richfield Springs	R. Springs	Ground limestone	....
	68. So. N. Y. Power & R. R. Corp., Cooperstown	Cullen	Ground limestone	....
	69. Allen Bleekman, Cherry Valley	....	Ground limestone	....
Putnam	No producers	....	....	....
Queens	70. Traitel Marble Co., Long Island City	L. Island City	Marble dust	....
Rensselaer	71. Hoosick Lime Co., Hoosick	Hoosick	Ground limestone	Small
	72. H. S. Osgood, Stephentown	Stephentown	Ground limestone	....
Richmond	No producers	....	....	....

TABLE 2.— PRODUCERS OF LIMING MATERIALS IN NEW YORK STATE, BY COUNTIES (*concluded*).

COUNTY	FIRM NAME AND ADDRESS	LOCATION OF QUARRY	KIND OF LIMING MATERIAL PRODUCED	CAPACITY
Rockland	No producers	....	....	....
St. Lawrence	73. Gouverneur Limestone Co., Gouverneur	Gouverneur	Ground limestone	....
	74. Maxner Quarry, Gouverneur	Gouverneur	Ground limestone	....
	75. Noel Aldous, Harrisville, Lewis Co	Pitcairn	....	....
Saratoga	76. Gailor Stone Co. Inc., Saratoga Springs	Saratoga Springs	Ground limestone	....
Schenectady	No producers	....	....	....
Schoharie	77. Frank L. Becker, Schoharie	Schoharie	Burnt lime	Large
	78. N. T. Smith, Sharon Springs	Sharon Springs	Ground limestone	....
	79. Norton Stone & Lime Co., Cobleskill	Cobleskill	Ground limestone	....
Schuyler	No producers	....	....	....
Seneca	80. Tunis Bishop, Seneca Falls	Fayette	Ground limestone	....
Steuben	No producers	....	....	....
Suffolk	No producers	....	....	....
Sullivan	No producers	....	....	....
Tioga	No producers	....	....	....
Tompkins	No producers	....	....	....
Ulster	81. J. A. Hiller, Hurley	Hurley	Burnt lime	Small
	82. John Basten, Stone Ridge	Stone Ridge	Burnt lime	Small
	83. Nathan Freer, Katsbaan	Katsbaan	Burnt lime	Small

	84. A. J. Snyder & Co., Rosendale	Rosendale	Burnt lime	Large
	85. H. L. Devoe, Accord	Accord	Burnt lime	Large
Warren	86. Jointa Lime Co., Glens Falls	Glens Falls	Ground limestone	Large
	87. Finch-Pruyn Co., Glens Falls	Glens Falls	Burnt lime	Large
Washington	88. Keenan Lime Co., Smith's Basin	Smith's Basin	By-product	Small
Wayne	89. W. A. Plummer Co., Palmyra	Calciana	Ground limestone	Small
	90. Butts Bros., Sodus	Sodus	Ground limestone	Small
	91. Dowd & Teachant, Red Creek	Red Creek	Ground limestone	....
	92. E. G. Klinck, Wolcott	Wolcott	Ground limestone	Small
Westchester	93. Upper Hudson Stone Co., 26 Courtland St., New York City	Ver Plank	Ground limestone	....
Wyoming	No producers	....	....	....
Yates	No producers	....	....	....

TABLE 3.— PRODUCERS OF LIMING MATERIALS OUTSIDE NEW YORK STATE.

NAME	ADDRESS	LOCATION OF QUARRY
94. Clifford L. Miller	280 Madison Ave., N. Y. City.	W. Stockbridge, Mass.
95. Grangers Lime Co	Hartford, Conn	W. Stockbridge, Mass.
96. Stearns Lime Co	Danbury, Conn	Danbury, Conn.
97. Bessemer Limestone Co	Youngstown, Ohio	
98. J. E. Baker Co	Bambridge, Pa	
99. Carbon Limestone Co	Youngstown, Ohio	
100. Clydesdale Lime & Stone Co.	Pittsburg, Pa	
101. Edison Portland Cement Co.	Stewartsville, N. J	
102. Kelley Island Lime Co	Cleveland, Ohio	
103. McKeefrey & Co	Leetonia, Ohio	
104. New England Limestone Co.	Adams, Mass	
105. Norwich Chemical Co	Buffalo, N. Y	
106. Pownal Limestone Co	N. Pownal, Vt	
107. Vermont Marble Co	Rutland, Vt	
108. Palmer Lime & Cement Co	New York City and York Pa	

REPORT

OF THE

Department of Bacteriology

R. S. Breed, *Chief in Research (Bacteriology).*

H. J. Conn, *Chief in Research (Soil Bacteriology).*

J. W. Bright, *Assistant in Research (Bacteriology).*

G. J. Hucker, *Assistant in Research (Bacteriology).*

M. W. Finch, *Assistant in Research (Bacteriology).*

TABLE OF CONTENTS

REPORT OF THE DEPARTMENT OF BACTERIOLOGY

THE PRODUCTION OF HIGH GRADE MILK WITH MILKING MACHINES UNDER FARM CONDITIONS *

JOHN W. BRIGHT

SUMMARY

1. In order to determine whether the cleaning methods for milking machines found successful at the Station were practical for the average dairyman, and applicable to types of machines other than the one in use at the Station, these methods have been tested at two dairies sending milk into Geneva. Conditions have also been observed at a third dairy where the dairyman had used methods of cleaning which produced good results.

2. The quality of the milk produced by the dairies previous to, and later than, the work described here was determined from the records of the bacteriological examinations made by the persons in charge of the milk inspection work for Geneva. These records were based upon a determination of the approximate numbers of bacteria present in the milk as brought to the city.

3. Trouble had been experienced at Farm A in continuously producing a milk with a low germ content. A ten-day visit was therefore made to this farm during which time the author observed conditions, and introduced cleaning methods similar to those used at the Station. Numerous tests of the milk showed that at this farm, at this time, the chief trouble arose from a failure to scald and dry metal utensils properly. The milking machine tubes were reasonably clean, and were kept in a solution of brine and chloride of lime which was in satisfactory condition, tho various details in the care given the tubes could have been improved. Improved methods were introduced with the result that, so long as the care of the machines remained under observation, all cans of milk sent to Geneva were found to have a low germ content. During the seven months that have elapsed since the visit was made, the

* Reprint of Bulletin No. 472, February, 1920.

quality of the milk from this farm, tho variable, has been better than it was previous to the visit. Observations lead the author to believe that the fluctuations in quality were due to a failure on the part of the dairyman to attend to all of the essential details of the cleaning process.

4. Trouble had also been experienced at Farm B in producing a high grade milk, and an eight day visit was made to study conditions. Investigation showed that there were many possible sources of trouble at this place, beginning with poor cleaning of the teat-cups and tubes, pails and other utensils. In addition, the sterilizing solution used for the rubber tubes was weak both in salt and in chloride of lime, while the milk was not cooled satisfactorily before shipping. The introduction of better methods of cleaning and caring for the utensils largely removed the difficulty, tho this was not cleared up entirely until the milk was cooled more efficiently. So long as these things were under control, the milk reached the city with a low germ content even tho it was shipped 27 miles without icing and was never cooler than 62° F.

5. A description of conditions at Farm C is also included because at this farm the dairyman himself had adapted the Station methods of cleaning machines to his own conditions so successfully that he had maintained an almost perfect record for producing milk with a low germ content. This record corresponded with the excellent record maintained by the same man during periods when his herd was milked by hand. Some difficulty which he experienced during the spring of 1919 disappeared following the use of a sterilizing solution for the teat-cups and tubes which contained salt as well as a strong solution of chloride of lime. Great care was maintained at this farm at all times to keep the machines as well as all other milk utensils in a cleanly condition.

6. The chief conclusions to be drawn from the observations are: that the methods of cleaning are more important than the type of the milker in determining the germ content of the milk, and that high grade milk can be produced with the milkers under observation provided they are cleaned and cared for twice a day for 365 days in the year by methods known to give good results. Success cannot be attained, however, by doing the work in a half-hearted way. The neglect of any one of several important details in the cleaning process may make all the difference between success and failure.

INTRODUCTION

The extensive use of the mechanical milker during the past four or five years has greatly complicated the problem of producing high grade milk. The milking machine with its rubber tubes, pail lid with milk spigots and valves, and, generally, a more or less complicated pulsator, and heavy pail requires much greater care than do the simple milk pails used in hand milking. While these parts entirely enclose the milk in its passage from the teat to the pail, and so protect it from contact with human hands and from sediment and dust, they may at the same time seed the milk with excessive numbers of bacteria.

Thus, while machine-drawn milk is, in one sense of the word, cleaner than the average hand-drawn milk, yet in another sense (if we regard the accumulation of bacteria in the milky material left in poorly cleaned tubes as dirt) the average machine-drawn milk is not as clean as hand-drawn milk.

As it is a relatively simple matter to protect machine-drawn milk from extraneous dirt and sediment, little attention is given this phase of the matter in the present bulletin, and the discussions are largely confined to the difficulties actually encountered by farmers in keeping the milk drawn thru the milking machine free from excessive numbers of bacteria.

If market milk is to reach the consumer as it should reach him, clean and pure and of good keeping quality, it must be carefully handled from the time it leaves the udder of the cow until it is delivered into the hands of the consumer. One of the most essential points in the handling is to see that all utensils into which the milk is poured or thru which it passes are thoroly clean.

The requisites for the successful care of the milking machine are: Plenty of hot water, a good washing compound, a rack for drying, a good sterilizing solution in a large crock, and a willingness to use care twice a day for 365 days in the year.

As a result of the ease with which machines become seeded with bacteria, the following method for the care of the machine has been developed at the Station. A rapid but *careful* washing of the machines by drawing successive pails of cold water, hot alkali water, and clear hot water thru them *immediately after every milking*; immersion of the teat-cups and all rubber parts in a good steril-

izing solution between milkings, supplemented by a very thoro weekly overhauling of the teat-cups and tubes; and the daily scalding and thoro drying of all the metal parts that with the milk except those parts lizing solution.[1]

eems rather complicated to many users and prospective buyers, use of the difficulty experienced in obtaining a good supply of hot water. In view of our experience with machines, however, it seems necessary to use an abundance of hot water, i. e., more than a tea kettle full, if the utensils are to be kept in a cleanly and essentially sterile condition. Inasmuch as the cleaning of the machines must be done at the barn or in the milk house, the hot water supply should be available at the same places. Where the barn is equipped with running water, a hot water tank and heating coil can be installed, and the coil heated by means of a wood or coal stove, a gas burner, or a kerosene burner. If there is no running water supply in the barn, then the water may be heated in a large boiler on a wood, gas, or kerosene stove placed in the milk room or some other safe place where the danger of fire is reduced to a minimum. Suitable outfits are shown in the illustrations. (See Figs. 7, 8, and 9.)

FIG. 7.—A CONVENIENT OUTFIT FOR HEATING WATER WITH WOOD.

[1] Harding, H. A., Wilson, J. K., and Smith, G. A. Milking machines: I. Effect of method of handling on the germ content of the milk, N. Y. Agr. Exp. Sta., Bul. 317. 1909. (Out of print.)

Smith, G. A., and Harding, H. A. Milking machines: II. Effect of machine method of milking upon the milk flow. N. Y. Agr. Exp. Sta., Bul. 353. 1912.

Ruehle, G. L. A., Breed R. S., and Smith, G. A. Milking machines: III. As a source of bacteria in milk. IV. Methods of maintaining in a bacteria-free condition. N. Y. Agr. Exp. Sta., Bul. 450. 1918.

These bulletins are also issued in a popular edition. Circular No. 54 gives methods of preparing sterilizing solutions, and the like.

Coupled with the use of plenty of hot water is the equally important process of proper drying of all pails and pulsators. To accomplish this, one should either erect a good drying rack out in the open air, where the utensils may be inverted and exposed to a maximum of sunlight and fresh air with a minimum of dust; or racks may be so arranged as to expose the utensils to the heat of the fire.

While the methods outlined have given good results as practiced at the Station for more than ten years, yet the farmers of the region about Geneva, who have introduced apparently similar methods of cleaning and caring for their machines, have generally failed to secure equally good results. As inspection of these dairies usually gave evidence that directions were not being followed in all details, a conviction gradually developed that this lack of attention to detail was the reason for the failure to produce milk free from excessive numbers of bacteria.

THE GENEVA MARKET MILK SUPPLY AS INFLUENCED BY THE USE OF MILKING MACHINES

Since 1915 the Station has been in charge of the milk control work for the city of Geneva.[1] During this time practically all the milk sent into the city has been distributed as Grade B pasteurized.[2] The milk is delivered by about sixty-five dairymen at two central receiving plants, and is there pasteurized and bottled for distribution. Samples for bacteriological analysis and sediment tests are collected on the platform from the individual cans before the milk is emptied into the receiving vats.

In the four and one-half years extending from February, 1915, until the first of July, 1919, 22,134 cans of milk have been examined for the purpose of exercising a control over the quality of the milk supply. Of this number, 5,351 cans were produced with the aid of milking machines, and 16,231 by hand milking, leaving 552 cans which can not be taken into account because of uncertainty as to the method of their production. During this time the percentage

---

[1] Breed, R. S., and Brew, J. D. The control of bacteria in market milk by direct microscopic examination. N. Y. Agr. Exp. Sta., Bul. 443. 1917.

Breed, R. S. Questions concerning the control of a city milk supply answered. N. Y. Agr. Exp. Sta., Bul. 456. 1918.

[2] See the Sanitary Code established by the Public Health Council of the State of New York. Chapter III. Milk and Cream. 1914.

of machine-drawn milk has varied from a minimum of 19.1 per cent in 1917 to a maximum of 30.1 per cent in 1918.

It is in the production of high grade milk, however, rather than in the production of milk in general that we are particularly interested, and an examination of the records shows that of the total number of samples graded during the four and one-half years, 18,758 (86.5 per cent) were graded as excellent or good, 2,478 (11.4 per cent) were graded as medium, and 536 (2.5 per cent) were graded as poor.[1] Sixteen thousand two hundred and thirty-one of these samples were of hand-drawn milk, and of this number, 14,608 (90 per cent) graded as excellent or good, 1,396 (8.6 per cent) graded as medium, and 227 (1.4 per cent) graded as poor. Five thousand three hundred and fifty-one of them were machine-drawn samples, and of these, 3,955 (73.9 per cent) graded as excellent or good, 1,153 (21.5 per cent) graded as medium, and 243 (4.6 per cent) graded as poor. These percentages are graphically represented in Chart I.

This chart shows that the bacterial quality of milk brought to the city would have been materially improved by the elimination of that brought from the farms where machines were used.

The detailed inspection records indicate that the amount of poor quality milk brought from the group of farms using machines was less than it would have been had no pressure been brought to bear upon these farmers. This pressure was very real in that one man was forbidden to bring milk into the city because of continued failure to keep his machine in a sanitary condition, while the premium which was paid for bringing in high grade milk was frequently withheld from men using milking machines because of the poor quality of their product.

---

[1] All grading has been done by direct microscopic examination of dried milk smears.

Excellent — Contained less than 300,000 individual bacteria per cc. Would meet the bacteriological requirements for a Grade A raw milk.

Good — Contained more than 300,000 and less than 1,000,000 individual bacteria per cc. Would meet the requirements for a Grade A pasteurized milk.

Medium — Contained more than 1,000,000 and less than 10,000,000 individual bacteria per cc.

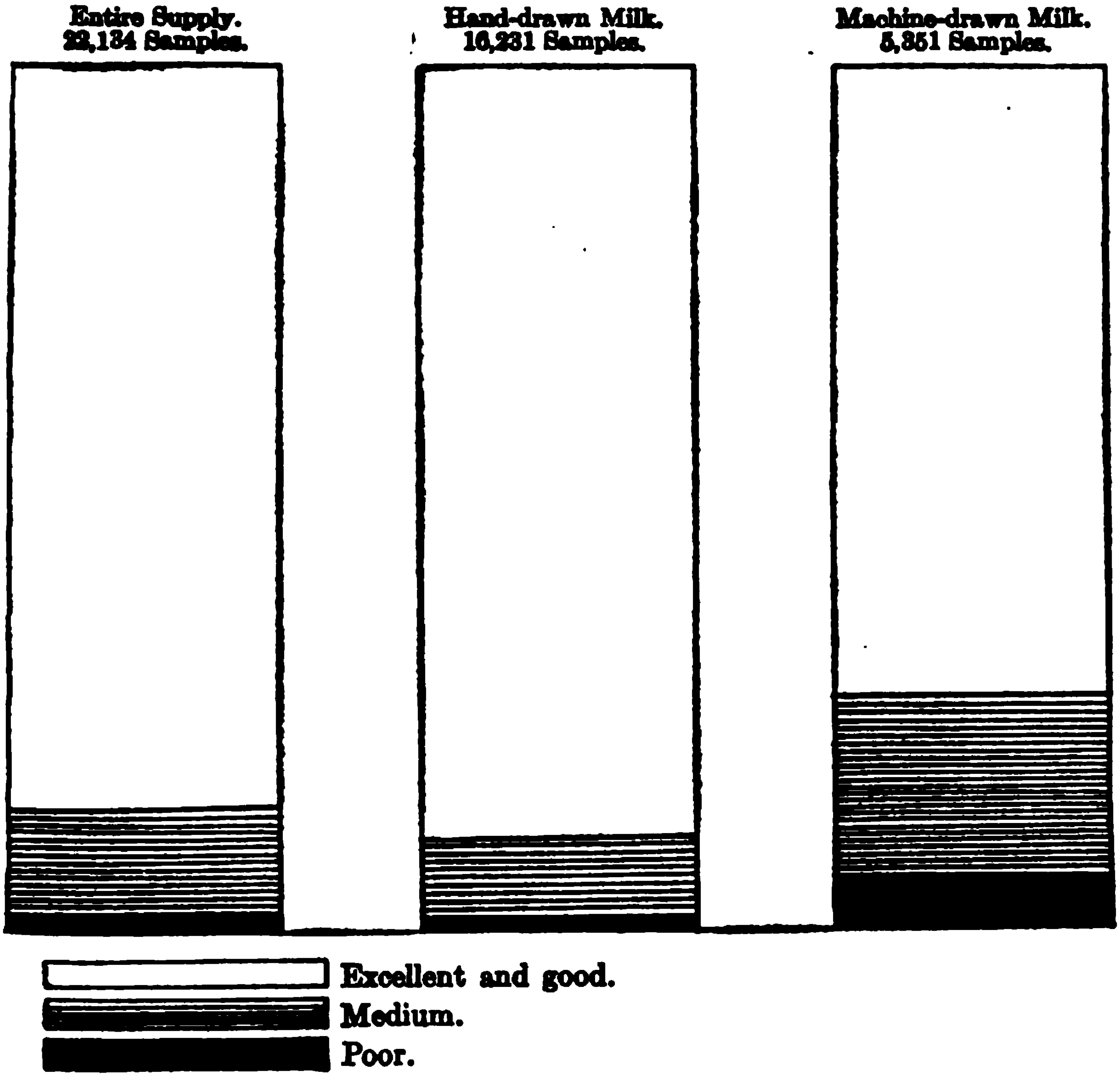
Poor — Contained more than 10,000,000 individual bacteria per cc. Would not even meet the requirements for a milk satisfactory for pasteurization as Grade B.

While the exact relation between these counts and the ordinary agar plate counts cannot be given, it should be stated that counts of individual bacteria usually average about five times the size of ordinary agar plate counts. See Tech. Bul. No. 49 for a description of the technique used.

Yet in spite of this pressure, the resulting conditions can scarcely be called satisfactory. Unless the men using milking machines can get as good quality milk as those men who practice hand milking, the hand milker will remain a severe competitor of the milking machine.

While it is the tendency of control officials to regard the chief problems presented by the present day milking machine as sanitary

CHART I.—QUALITY OF GENEVA MILK SUPPLY, 1915–1919.



ones, the average dairyman who is operating the machine is inclined to think that mechanical defects constitute the principal difficulties. Not so much mechanical defects of the machine itself, perhaps, but rather of the gas engine that is generally used to furnish the power to operate the machine. Wherever gas engines are used there is frequently more or less trouble, particularly if the operator is not mechanically inclined. But so far as machines themselves are

concerned, experience shows that they are reasonably successful from the mechanical standpoint.

However, it can scarcely be claimed from the sanitary standpoint that the manufacturers of machines have even yet given sufficient attention to proper construction. They have not realized the importance of eliminating all possible seams or crevices that gather dirt. Likewise, not all manufacturers have given sufficient attention to the construction of leak-proof valves at the point which guards possible leakage into the milk from the main vacuum line. This line cannot be cleaned satisfactorily with methods ordinarily available, and may become foul with milky vapor, condensation water, and like material. Even a drop of this material in a single pail of milk produces a detectable contamination.

Further study could profitably be given by many of the manufacturers to the selection of suitable metal alloys for use in the teat-cups and pulsators. These should be such as are not corroded by the commonly used washing compounds and sterilizing solutions. It would also be very desirable if a standard grade of rubber were used for tubes and inflations; one which would withstand the action of the animal fats, a generous use of hot water, and which would have fairly uniform wearing qualities.

PRACTICAL EXPERIENCES ON FARMS USING MILKING MACHINES

As a result of the failure of some nearby dairies to produce high grade milk, the writer visited two farms to watch operations closely, and then to operate and clean the machines in order to introduce such procedures as were necessary in order continuously to produce good milk.

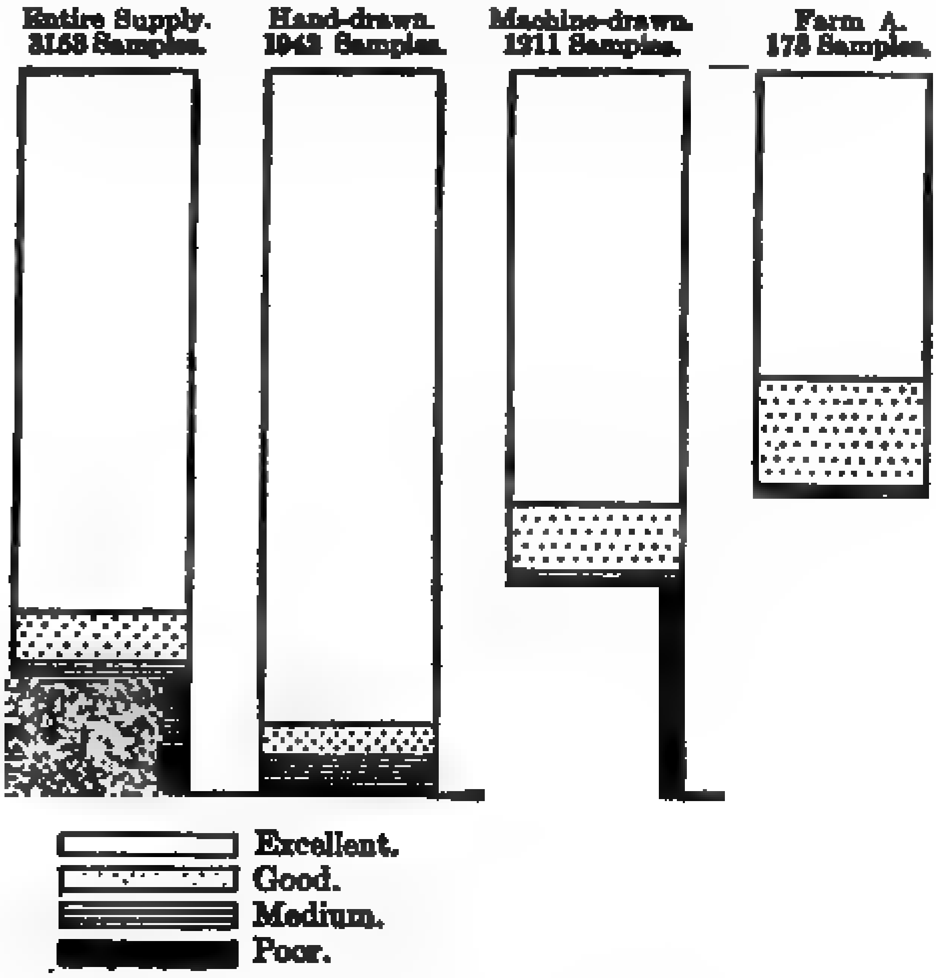
FARM A

Considerable trouble in producing a low count milk had been experienced at this farm. Two Empire units had been in use there for some time. Since the milk had started to come into Geneva from Farm A in August, 1918, 175 cans of milk had been examined up to May 17, 1919, at which time the investigation began. Of this number, 94 (53.6 per cent) were graded[1] as excellent, 26 (14.8 per cent) were graded as good, 38 (21.7 per cent) were graded as medium, and 17 (9.9 per cent) were graded as poor.

[1] See footnote on p. 124.

The average of all the milk (3,153 cans) examined at the Station during the same period was as follows: 79.7 per cent were graded as excellent, 6.9 per cent as good, 10.3 per cent as medium, and 3.1 per cent as poor. Of the 3,153 cans, 1,942 were hand-milked, and 90.5 per cent of these were graded as excellent, 4.4 per cent as good, 4.5 per cent as medium, and 0.6 per cent as poor. The total number of machine-milked samples tested was 1,211, of which

CHART II.— QUALITY OF MILK FROM FARM A AS COMPARED WITH THE QUALITY OF THE GENERAL MILK SUPPLY, AUGUST, 1918 TO MAY, 1919.



only 62.2 per cent were graded as excellent, 11.2 per cent as good, 19.4 per cent as medium, and 7.2 per cent as poor. These percentages are graphically shown in Chart II.

The chart shows very clearly that the milk coming from Farm A was far below the average in quality for milk coming from all the farms regardless of the method of production, and that it was also considerably poorer in quality than the average machine-produced milk.

At the time the investigation started at Farm A, everything about the dairy farm was in fairly clean condition. The barn itself was

This water also had to do double duty, and by the time it had finished its task of washing out two double units, and a couple of stripping pails it was cold and greasy. After this treatment, the cups and tubes were again put into the solution, and the pails and lids were turned upside down on a bench in the barn until milking time the following morning. Examination the next morning showed them still to be wet and greasy. Twice a week the machines were taken in their entirety to the house for a thoro cleaning, and at this time they were taken entirely apart and washed.

For the first four or five days that the investigation was being carried on at Farm A, no definite or detailed system of caring for the machines was carried out. As noted in the remarks in Table I, one procedure was tried at one milking, and another at the next. This system, or rather lack of system, was used to determine whether any particular step in the care of machines and utensils was the one absolutely necessary step upon which depended the production of high grade milk. As shown in column four of the table, the quality of the milk as delivered at the milk receiving stations varied greatly under these conditions. It was not until the detailed methods recommended by the Station were put into practice on May 25 that a consistently good product was obtained.

Duplicate samples were taken from every can of milk after each milking. Preparations for microscopic examination were made immediately from one set of samples and the other set was put into the cooling tank to stand for twelve or twenty-four hours as the case might be. By this method we were able to determine the grade of A. M. milk as it was received at the milk plants, and as it was after standing for some hours; and also the grade of the P. M. milk after milking, and then again sixteen hours later, or as it was when delivered to the receiving plant.

The first corrective step taken was the removal of the screw cap at the end of the claw of the teat-cups before putting the cups into the solution after each milking. This was done in order to allow the escape of air from the milk tubes and to insure free passage of the solution thru the tubes in order that the sterilizing function of the solution could be fully utilized.

In other respects the procedures for caring for the machines and utensils were allowed to remain the same as usual. Care was taken, however, to see that no leaky inflations were used, that plenty of

FIG. 8.— OUTFITS FOR HEATING RUNNING WATER WITH KEROSENE AND COAL.

FIG. 9.— OUTFIT FOR HEATING RUNNING WATER WITH GAS.

Fig. 10.—Farm A. Interior Dairy Barn.

Fig. 11.—Farm A. Solution Jar.

Fig. 12.— Farm B. Solution Jar.

Fig. 13.—Farm B. Interior Dairy Barn.

Fig. 14.— Farm C. Interior Dairy Barn. Solution Jar May be Seen in Background.

Fig 15.— Farm C. Solution Jar.

cold water was used in rinsing out the tubes and milker pails after each milking, and that the udders of the cows were clean before the teat-cups were attached. Table I shows that the milk quality under these conditions varied considerably, and during this time seven cans graded as excellent, five as good, and two as medium when received at the milk plant in Geneva.

Just before the fifth milking, two pails full of very hot water were drawn thru the milker tubes into the machine pails. This procedure thoroly scalded both the tubes and the pails. The results were gratifying as the four cans of milk produced under these conditions all graded as excellent.

No more hot water was used for a time, but efforts were made to keep the quality "excellent" by the use of a combined cooler and aerator. This aerator was of the open, tubular type, and, with its use, the milk could be cooled to about 45° F. The first time that the cooler was used the results were satisfactory as the first can graded as good, and the other two as excellent. The next time one can graded as medium, one as good, and one as excellent. The third time two cans graded as medium and two as good. This gradual lowering in the quality of the milk was probably due to the fact that the cooler was being inefficiently cleaned, and it illustrates very strikingly a common source of milk contamination.

Evidently cooling alone was not sufficient to produce first-class results. In order to get good quality milk, it is evident that it must first be handled in clean utensils so that it does not contain large numbers of bacteria. Cooling merely stops the growth of bacteria and does not reduce their numbers.

For the next two milkings, the procedure that had been in use before our work started was again used, but no real improvement was shown, as three cans graded medium and four good.

At this time it was decided to follow the methods that have been successfully used at the Station in exact detail. Immediately after milking, the tubes and pails were washed by drawing a pail of cold water thru the tubes into each milker pail. This was followed by a pail of hot soda water and a pail of clear hot water. The tubes and cups were then put into the sterilizing solution with the caps removed from the claws. The pails and pail covers (with the exception of the pulsators proper) were thoroly scalded and dried. This treatment also included the forty quart milk cans and the aerator.

A glance at the results from the last five milkings given in Table I shows that they were all that could be desired. Out of the twenty cans of milk produced under these conditions, the entire number graded as excellent.

From tests made during the course of the work it is evident that the chief source of trouble at this particular time was probably the metal utensils. The milker pails were clearly in bad shape for a liter of sterile water used for rinsing them gave agar plate counts of 1,500,000 and 240,000 per cc. The strippings pails under the same conditions gave counts of 70,000 and 340,000 per cc. Pails containing numbers of organisms as large as indicated from these counts would add enough bacteria to five quarts of milk to cause it to be rated below the excellent class even if no bacteria were present from any other sources.

Proof that scalding and drying these utensils did cause the disappearance of excessive numbers of bacteria is furnished from the fact that after this procedure was adopted (May 25) every can of the twenty examined was found to grade in the excellent class. Of the thirty-three cans examined immediately previous to this date only thirteen had graded in the excellent class.

It has been noted in the examination of milk from the dairies where milking machines were in use that there is often a higher bacterial count in the milk of one out of a number of cans containing milk from the same milking. Frequent repetition of this fact led to the thought that the can with the highest count was probably the first can filled and that the milk in this can had been contaminated by the first rinsings from the tubes and pails of improperly cleaned milking machines.

In order to verify this theory a record of the order in which the cans were filled was kept for several days at Farm A. The milk in these cans was sampled and graded.

Table I shows that in eight cases where this was done (May 20 to May 24) the first one or two cans filled had a higher bacterial count than did the rest of the cans of the same milking.

Altho the cases observed were few in number, yet they serve to justify the theory that the presence of a higher bacterial count in one of a number of cans containing milk from the same milking is

due to the fact that it contains the first rinsings from poorly cleaned milking machines or other utensils.

During the course of the work at Farm A the dairyman asked why it was that, despite the fact that the milking machines were really receiving less care previous to the morning milking than they did for the afternoon milking, yet the morning milk as received at the milk plant was almost invariably in the better condition. It was pointed out to him that this was probably due to the fact that the night's milk was not sent in to the receiving station immediately, and was not examined and graded until it was about sixteen hours old. The morning's milk, on the other hand, was received and graded when about four hours old. The twelve hours difference in the age made a great difference in the bacterial content as the milk was not held at a temperature low enough to prevent the growth of bacteria.

To illustrate this point, samples of morning milk were held for sixteen hours, and at the end of that time the grades were determined.

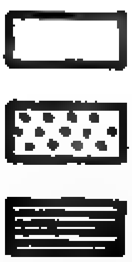
Chart III shows that of 23 samples of morning's milk examined and graded when four hours old, or as delivered at the receiving plant, 61 per cent were excellent, and the rest good or medium. Sixteen hours later, however, duplicate samples of the same milk graded only 45 per cent excellent. Of 19 samples of night's milk examined and graded when four hours old, 79 per cent were excellent, but after holding duplicate samples for sixteen hours, or the age at which the milk was delivered at the receiving station, this percentage had decreased to 63. Evidently, when compared with night milk of the same age, the morning milk was in poorer condition.

The records of the milk inspection work for this farm during the remaining months of the year do not indicate that even this demonstration caused sufficient care to be used in cleaning the machines. During the seven months that followed, 104 cans of milk were examined. Of this number only 75 (72.2 per cent) graded as excellent, 12 (11.5 per cent) as good, 15 (14.4 per cent) as medium, and 2 (1.9 per cent) as poor. In November a visit was made to the farm, and at this time it was evident that several

essential procedures in the care of the tubes were being neglected; for example, the tubes in the solution were again found to be largely filled

CHART III.—COMPARATIVE QUALITY OF A. M. AND P. M. MILK HELD 4 AND 16 HOURS RESPECTIVELY AT 55° F.

A. M. 4 hrs.	P. M. 4 hrs.	A. M. 16 hrs.	P. M. 16 hrs.



Excellent.

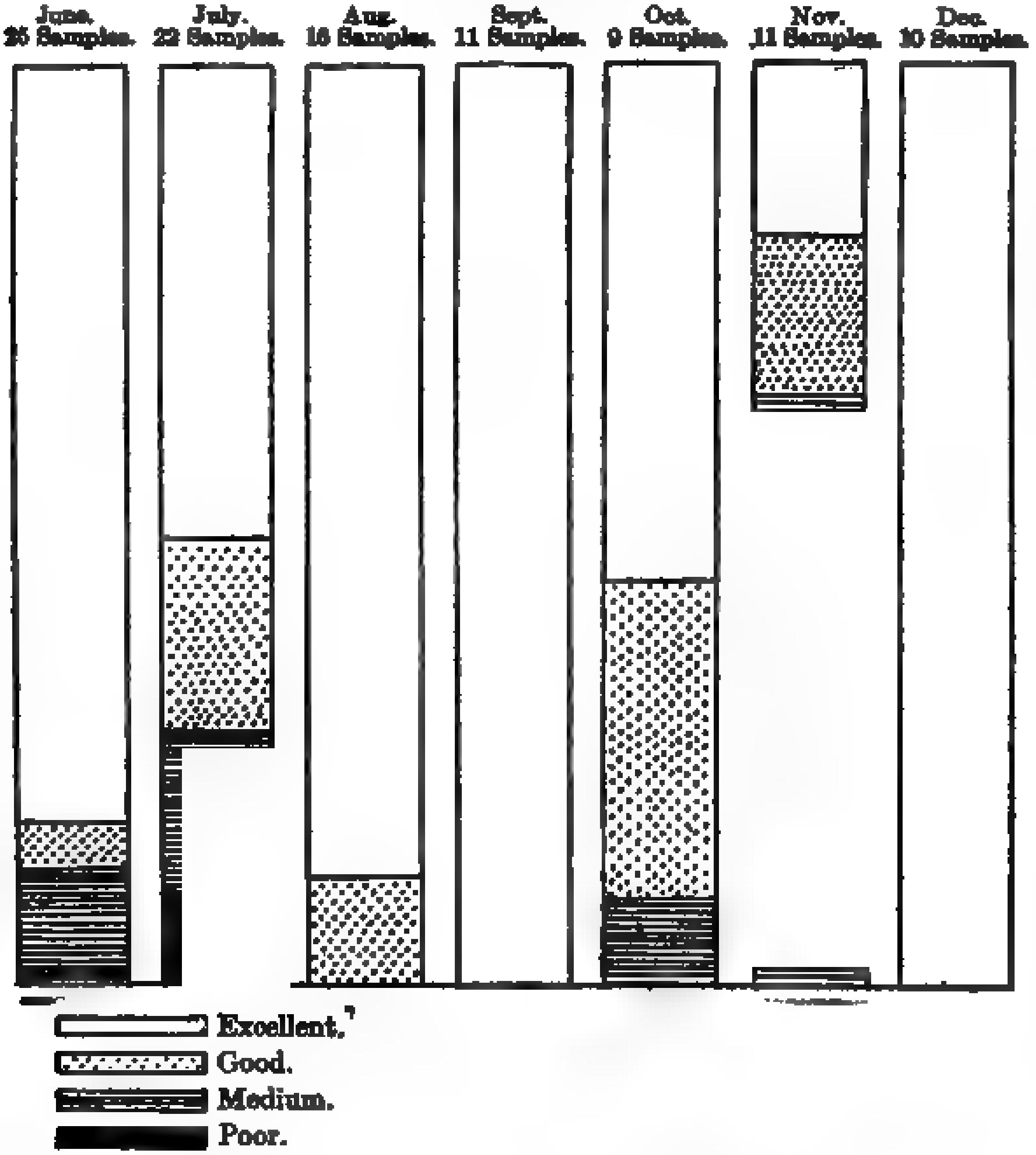
Good.

Medium.

with air, the caps on the ends of the claws were not being removed, and the solution itself contained very little chloride of lime.

On the average this record was an improvement on the record maintained before the demonstration of proper methods was made at the farm. However, when plotted by the individual months as shown in Chart IV, it is seen to be characterized by a great irregularity evidently not correlated with temperature.

CHART IV.— QUALITY OF MACHINE-DRAWN MILK FROM FARM A DURING LATTER PART OF 1919.



Thus the poorest quality milk was delivered in July and November, while these bad months were in each case followed by records which were excellent.

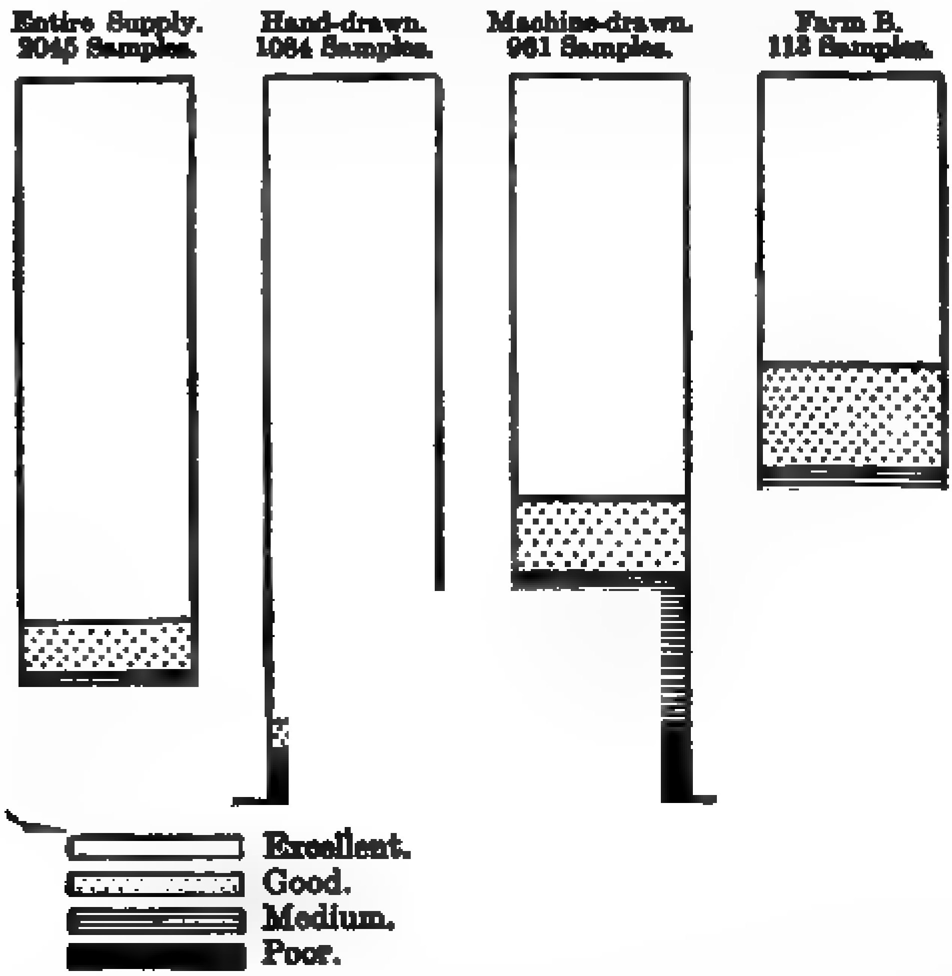
Investigations made by enquiry at the farm makes it probable that the bad records were correlated with failure to carry out the

cleaning procedure with care; and that the good records, immediately following the bad ones, were brought about by increased attention given after notice that the milk was being received in poor condition.

FARM B

Three units of a Sharples machine had been in use at this farm for some time before the investigation began. Since the milk had

CHART V.— QUALITY OF MILK FROM FARM B AS COMPARED WITH THE QUALITY OF THE GENERAL MILK SUPPLY, NOVEMBER, 1918 TO JUNE, 1919.



started coming into Geneva in November, 1918, 113 cans had been examined up to June 1, 1919. Of this number, 45 (39.8 per cent) graded as excellent, 18 (16 per cent) as good, 37 (32.7 per cent) as medium, and 13 (11.5 per cent) as poor.

As shown in Chart V these percentages compare very poorly with the averages showing the quality of the entire milk supply during the same time, or even with the quality of the average machine-produced milk.

A general inspection of the dairy barn and equipment at the beginning of the work showed that, while they were up to a good standard in construction (see Fig. 13), they were being poorly kept. Manure had been allowed to accumulate on the cement platform behind the stanchions, and this made it difficult to keep the milker pails and other utensils clean.

There was a good supply of running cold water in the barn and in the milk room, but no provision was made for hot water, except that it could always be procured at the house which was not very far away.

The cooling tank was a large concrete vat in the milk room. This was filled with cold water at each milking time, and the cans set in it up to their necks. This was later fitted with a drain so that a stream of cold water was constantly supplied.

The cows were kept fairly clean, but little attention was being paid to the condition of the udders when the teat-cups were put on, and oftentimes they were dirty.

The solution used for the teat-cups and tubes was in a 25 gallon crock and was mechanically clean. (See Fig. 12.) Altho the weather was very hot, the solution contained no hypochlorite and insufficient salt, so that it was not effective as a sterilizer.

The vacuum pipe line contained a few drops of moisture after each milking, and a milky spray drained out of the vacuum tank trap and the compressed air tank when the stop cocks were opened after milking.

The machines themselves were dirty. Altho the dairyman had supposedly cleaned them the day before the investigation started, a casual examination showed them still to be dirty. When questioned as to his methods for cleaning, it was found that he practically never removed the nipples from the bottom of the teat-cups nor even took off the short milk tubes from the cups. The cups and tubes were simply put into warm water, and a brush was run thru them a few times, they were then rinsed in hot water, and the cleaning was finished. This procedure was insufficient, and a coating of fat and dried milk was left on the inflations and in the tubes. The check valve and milk spigots on the pail lids fared no better, and much dried milk was found on the strainers in the check valve, on the valve seats, and on the valve plugs.

Each morning after milking, the machine pails (three in number) and the large milk cans (generally three or four) were rinsed out with about a kettle full of hot water, and turned upside down to dry. The cans were put on a rack outside the milk house, and the pails in the milk house on a rack built over the cooling vat. After the evening milking the pails and tubes were simply rinsed out by sucking a pail of cold water thru them. The pails were then put on the racks to dry, and the tubes were put into the sterilizing solution. No hot water was used. Also the caps were left on the milk claws when the cups and tubes were put into the solution, a good deal of air being imprisoned in the tubes, with the result that the solution was not able to act upon all the inside surface of the tubes.

For two milkings after our work began at Farm B, no change whatever was made in the methods used. Of the six cans produced during these two milkings, three were excellent, one was medium, and two were poor. The three excellent cans were the A. M. cans which were graded very soon after being filled. When this same milk was examined sixteen hours after being drawn, during which time it had been standing in the cooling vat, one can graded as poor, one as medium, and one as good. This indicated a high initial count which came, in all probability, from the machines and utensils, as all the udders seemed to be in good condition, and very few garget organisms appeared in the milk smears examined.

Before the next milking, all metal and rubber parts of the machines were thoroly cleaned with hot alkali water and rinsed with clear hot water. The machine pails, strippings pails, and large milk cans were scalded and dried. The rubber inflations in the teat-cups were in bad condition, and three of them had to be replaced with new ones. A strong hypochlorite solution was made up by mixing a can of chloride of lime with a gallon of water, and pouring off the clear greenish liquid. The rubber parts were all soaked in this for about an hour before assembling them again. A pint of the stock solution of hypochlorite was also added to the brine solution in the crock.

After the evening milking, the tubes and pails were washed out by drawing thru them: First, a pail of cold water; second, a pail of hot soda water; and third, a pail of clear hot water. The cups and tubes were then put into the brine solution. The screw caps

on the milk claws were removed and kept in a box beside the solution jar. The milk and pail lids were turned upside down on the rack out in the open air to dry.

At every milking care was taken to be sure that the udders of the cows were clean before the cups were attached, and efforts were made to prevent any dirt from getting into the milk pails and cans.

TABLE II.— QUALITY OF INDIVIDUAL CANS OF MILK FROM FARM B DURING THE EARLY PART OF JUNE, 1919.

Test No.	Date.	Time of milking.	Grade of milk after four hours.	Age of milk when examined the second time.‡	Grade of milk.	Remarks.
	1919					
1...	June 2	P. M.	....	16 hrs.	P-P-M†*	Cleaning as usual. Temperature of milk as shipped—62° F.
2...	June 3	A. M.	E-E-E†*	16 hrs.	P-M-G	As above. Milk not cooled before shipping.
3...	June 3	P. M.	E-E-E	16 hrs.	M-E-E*	Machines thoroly cleaned. Pails scalded and dried. Cooled in vat to 62° F.
4...	June 4	P. M.	....	16 hrs.	E-E-E*	Machines cleaned as at Station. Cooled as in No. 3.
5...	June 5	A. M.	E-E-E*	28 hrs.	M-M-M	As above. Not cooled before shipping.
6...	June 5	P. M.	....	16 hrs.	G-G-E*	As above. Aerator used for first time. Cooled to 64° F.
7...	June 6	A. M.	E-E-E-E*	28 hrs.	G-G-M-M	As above.
8...	June 6	P. M.	....	16 hrs.	E-E-E*	As above. Well water used in aerator. Cooled to 60° F.
9...	June 7	A. M.	E-E*	......	....	As above.
10...	June 7	P. M.	....	16 hrs.	E-E-E*	As above.

† Each letter indicates the quality of the milk in a single 40-quart can. E—excellent, G—good, M—medium, P—poor. See footnote on page 124.

* Samples for the tests indicated by an asterisk were taken from the cans as the milk left the farm for the pasteurising plant.

‡ Cooling at this farm was accomplished by running spring water which was never colder than 60° F. during this period. Milk held on the farm longer than four hours was kept in the cooling vat, and usually had a temperature of from 62 to 65° F.

Note.— Total number of cans examined—30. The grades when they were sent to the city were as follows: 24—excellent, 2—good, 2—medium, 2—poor. Twenty-one cans were produced after Station methods of cleaning were used. Nineteen of the latter graded excellent and two good.

The results under these conditions were excellent until the third milking, at which time one can graded as excellent, and two as good.

The usual precautions had been taken previous to this milking, and an aerator had been added to the equipment already in use. It was found, however, that the milk was being cooled to only 64° F., so that, after standing for about sixteen hours (as the night milk did before being delivered to the receiving plant), whatever organisms were present had ample opportunity to multiply rapidly. For the bacterial count to remain low for so long a time at this tempera-

ture, all utensils would need to be in very excellent condition, and great care would need to be taken continually during milking.

It was a significant fact that the samples graded as good showed a high count of lactic acid organisms, and very few of the type commonly regarded as " utensil " organisms.

By the next milking, the cooling conditions were changed so that the milk was cooled below 60° F., and from then on until the end of the work no further trouble was experienced, and all cans graded as excellent.

In order to determine the germ content of the three milker pails under the methods of washing that had prevailed on the farm before the system of scalding and drying the utensils had been introduced, the pails were rinsed out with a liter of sterile water on June 3. This water when plated out and incubated gave counts of 20,000 to 53,000 per cc. If five quarts of milk were drawn into pail number two, which contained the greatest number of organisms, it would result in an initial contamination of about 10,000 organisms per cc. of milk. This does not indicate satisfactory conditions tho the result is much better than that secured at Farm A where the rinse water gave counts up to 1,500,000 per cc.

It was very disappointing to us to find at the conclusion of our work at Farm B that the milk from this farm was to be sent to a nearby creamery in order that the skim milk might be available for stock feeding. As a consequence, inspection of the quality of this milk was discontinued until the following November, when the milk was again sent to Geneva.

The record for November was not satisfactory as only six (50 per cent) of the samples of milk examined were graded as excellent, while three were graded as good, and three as medium. December's record, however, was good, as all samples examined, fourteen in number, were graded as excellent.

FARM C

As a contrast to the farms under discussion, let us briefly review the history of Farm C. The dairy barn on this farm is not a strictly modern building, but it is kept reasonably clean, and there is a plentiful supply of light and air. (See Fig. 14.) Due to the fact that the cows must frequently come thru a muddy yard to get into the barn, their udders are sometimes dirty so that Farmer C washes

them carefully with warm water. A double unit Empire machine has been used on this farm since May, 1917, and the quality of the milk produced has been good up to the present time. From May, 1917, until January 1, 1920, 274 cans of milk from this farm have been examined, and of this number 266 (97.1 per cent) have been graded as excellent or good, 7 (2.5 per cent) as medium, and 1 (0.4 per cent) as poor. The record at this farm since the machines have been in use compares very favorably with the record of the same farm when the cows were milked by hand. In Bulletin No. 450 of this Station, the statement is made that "On six farms where direct comparisons between hand-drawn and machine-drawn milk were possible, only two of them produced milk by machine with as few germs as were contained in the milk produced by them by hand." Dairyman C is one of the latter.

In general, the cleaning methods recommended by the Station have been in use on this farm with the exception that, after each milking, the tubes and cups are washed out only by sucking cold water thru them. At Farm C, however, they are very careful to scald all utensils out thoroly after every milking. Everything that in any way comes in contact with the milk is kept scrupulously clean. Until very recently, the cups and tubes have been kept in a strong chloride of lime solution, except in the winter when brine was added to keep the solution from freezing. (See Fig. 15.) Great care has always been taken, however, to keep the chloride of lime up to strength, and in June, 1918, at one test the solution showed 888 parts per million of available chloride. This indicates a very active sterilizing solution.

During this last summer trouble was encountered in maintaining the excellent record made up to that time. In April the records showed eight cans excellent, one can good, and three cans medium; in May, four were excellent, two good, and two medium; and the first test in June showed two excellent and two medium cans. An examination of the microscopic preparations showed that a yeast was commonly present, a condition which is in itself somewhat unusual. Following the examination of the milk on June 4 the dairyman was instructed to add brine to his chloride of lime solution and, tho it may be a coincidence, it is a fact that since that time every can examined has graded as excellent or good (32 excellent and 2 good).

The important points to note in regard to this record are the following: In the first place all of the utensils with which the milk comes in contact are being kept very clean. This important rule is being faithfully observed. As a general rule, the producer and his wife attend to the care of the dairy themselves, so that this work is not left to hired help, which is often either incompetent or indifferent. In the second place, the solution in which the cups and tubes are kept is always sweet and clean. In this connection it might be well to point out that it does not matter so much where the solution is kept as how it is kept. In this particular case the solution crock is kept in the barn with the cows. (See Fig. 14.) In the third place the cows are always kept clean. Fourthly, the milker himself is clean. Finally, the barn is kept in good condition. *This combination of affairs has resulted in the establishment of an excellent record, and is proof that, with proper care and attention, good milk can be produced with a milking machine under practical farm conditions.*

CONCLUSIONS

An examination of the methods applied at Farms A, B, and C, together with the results secured, show that, while machines are quite complicated, yet clean milk can be secured with them if proper precautions are taken. It also shows that these precautions are such that they come within the limits of the ability of every dairyman. The all-important principle which must be kept in mind is strict attention to detail. No matter if two essential rules are always carried out to the letter, if a third is occasionally neglected the results are sure to be irregular. If every detail is carried out every time, however, the results will always be satisfactory.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Dr. R. S. Breed for his suggestions during the work and his criticisms of the manuscript.

Acknowledgments are also made to the city of Geneva for the use of data relating to the city milk supply during the last five years, and to Mr. G. J. Hucker for the photographs appearing in the bulletin. During the period discussed in the present bulletin, the milk

inspection was carried out by Mr. J. D. Brew, formerly of the Station Staff, and by Mr. Harold Macy and Miss M. A. Davis, formerly bacteriologists for the city of Geneva.

Thanks are also given to the owners of the farms where the investigations were made for courtesies extended during the work.

THE ACCURACY OF BACTERIAL COUNTS FROM MILK SAMPLES*

R. S. BREED AND W. A. STOCKING, JR.†

SUMMARY

1. Three series of bacterial counts from samples of fresh, unpasteurized milk have been completed. Six or seven analysts participated in each, working in two groups in laboratories located within fifty miles of each other.

2. In all cases, counts were made both by the agar plate method and by direct microscopic examination, thus permitting a check upon the accuracy of the counts not possible where only one method of counting is used.

3. In two series (B and C), the samples analysed were carefully prepared so as to present the most favorable conditions possible for accurate counting and to allow checks to be made upon the accuracy of the results. This was accomplished by inoculating three lots of freshly drawn milk, known to contain very few bacteria, with a skim milk culture of the colon organism. The amount of inoculum used was such that the final counts were expected to show the ratio 1:2:4. The colon organism was chosen because it grows well under normal conditions, and exists in milk largely as isolated individuals.

4. Under the above conditions, the results met all of the checks upon their accuracy so perfectly that there can be little doubt but that they actually were fairly accurate counts of the number of individual bacteria present.

5. The results obtained in the final series (C) were so uniform that the coefficient of variability was reduced to less than 15 in all cases. Under the conditions present, the variability of the microscopic counts was slightly greater than that of the agar plate counts.

6. In the counts made from samples containing a miscellaneous flora (Series A), wide variations were found between the plate and microscopic counts. The primary cause of these variations appeared to be the existence of clumps of bacteria which were not separated

* Reprint of Technical Bulletin No. 75, January, 1920.

† Analyses made by R. S. Breed, J. D. Brew, H. J. Conn, W. D. Dotterrer, and G. L. A. Ruehle from Geneva, and A. M. Besemer, H. M. Pickerell, T. J. McInerney, and G. C. Supplee from Ithaca.

into their component individuals in preparing the agar plates. The uniformity of the agar plate counts was generally good indicating that the technique used was satisfactory. The greater lack of uniformity in the microscopic counts was in part due to the inexperience of some of the analysts, several of whom had never before attempted to make accurate counts by microscopical methods.

7. The average number of individuals in the clumps of bacteria present commonly varied between two and six; but at times (when streptococci were present) greatly exceeded these numbers. As the data indicate that the clumps are only very poorly broken apart in the processes ordinarily used in preparing dilution waters, the plate counts did not represent the full number of bacteria present.

8. The chief limitations upon the accuracy of the microscopic counts appear to be those involving the skill of the analyst making the microscopic observations, and the patience necessary in order to examine a sufficiently large quantity of milk to give an accurate average. Given unlimited time, and numerous duplicate preparations from a sample of milk, a skilled microscopist can secure reasonably accurate counts of the number of individual bacteria present in any ordinary sample of milk. Yet the laboriousness of this proceeding limits its usefulness, and makes it impossible to actually count the bacteria in examining large numbers of samples.

9. Fortunately neither the inaccuracy of the plate counts caused by the clumping, nor the limitations of the microscopic technique just noted, appear to be so great as to prevent the use of either technique where the purpose is to grade miscellaneous samples of unpasteurized milk into two or three grades. However, the information at present available indicates that attempts to use simplified methods for analysis for the purpose of making finer distinctions in quality introduces gross errors. When a finer classification is desired (as is now the case in many grade A plants) the use of the so-called simplified routine control methods should not be regarded as satisfactory. The present situation suggests the desirability of the State exercising control over bacteriological methods for analysis, whenever the results are to be used as a basis for payment, in order to insure the use of more accurate methods of analysis just as it now does in the case of the Babcock test for determining the percentage of butter fat.

INTRODUCTION

At the present time all of the market milk sold in New York State is graded on a system based upon the number of bacteria present in the milk. Likewise, an increasing amount of milk is being bought from dairy farmers on the same basis. This makes it important to

all concerned that the methods of analysis used in the grading should be sufficiently accurate to justify the use made of them.

Because of questions that have been raised in regard to the matter, a series of coöperative analyses of milk samples have been made, the results of which are discussed in the present bulletin.

PREVIOUS STUDIES

Because of the importance of the matter, numerous series of comparative analyses have previously been made in many of the public and private bacteriological laboratories in the State; but the primary purpose of the majority of these tests has been merely to determine whether different analysts, working in the same or in different laboratories, could secure duplicate agar plate counts which were in close agreement.

The results secured have been such as to cause the majority of bacteriologists to feel that reasonable agreement could be obtained where the counts were made by a standard, uniform technique by trained analysts. Yet it has become increasingly evident that carelessness or slight modifications of essential procedures may produce widely divergent counts. The most extensive of the recent series of analyses is that made under the supervision of the late Prof. H. W. Conn.[1] Other recent series are those discussed by Hatfield and by Kilbourne.[2]

It should not be forgotten, however, that the securing of closely comparable counts of bacteria from duplicate samples by different analysts where but a single method of analysis is used *does not prove that the counts obtained are an accurate or even a reasonably accurate count of the actual number of bacteria present.* It is easily possible that such counts are affected by a constant source of error which affects all duplicate counts proportionately. Or it may even be possible that variable errors completely destroy the accuracy of the counts, even tho there is no indication of their presence in the final counts.

For example, in the case of agar plate counts from milk, constant errors in count would be produced if all bacteria in milk existed in clumps of a constant average size. Such a condition would not be indicated in the counts as all would be reduced proportionately. Thus, if the average clump contained two individuals, all counts would be reduced to one half of the number of bacteria actually present. It may justly be argued that such an error would have no

[1] Conn, H. W. Standards for determining the purity of milk. U. S. Pub. Health Service., *Pub. Health Rpts.*, 30, 2349–2395. 1915.

[2] Hatfield, Hazel M. A comparative study of milk plates by four New York laboratories — A preliminary report. *Amer. Jour. Pub. Health*, 8, 913–915. 1918.
Kilbourne, Chas. H. Varying bacteriological results obtained by different laboratories. *Creamery and Milk Plant Monthly*, 7, Nos. 10 and 11. 1918.

practical significance because its presence would be already discounted in the standards established for each grade of milk.

The great uncertainty in the present situation does not arise because it is thought that errors of this type exist; but because microscopic examination has shown that the average size of the clumps of bacteria in milk is not constant. In such a situation, the results are, undoubtedly, liable to inconstant errors of such a type that they pass undetected in comparative series of analyses made by the agar plate method. Thus, while all of the counts made from one lot of milk may be reduced to one half their true size by the presence of clumps containing an average of two individuals, another set of duplicate counts may be reduced to one third of their true size, another to one sixth, another to one twenty-fifth, etc.

It is this condition of affairs that has made the development of a second, fundamentally different, method of counting bacteria in milk doubly important. Microscopic methods of counting have now been so perfected[1] that it is possible not only to secure data regarding the actual size of the clumps of bacteria in milk, but also to make comparative analyses of a series of milk samples both by the usual agar plate method and by direct microscopic examination. This permits us to study the accuracy of the counts in a manner not heretofore possible.

Already extended series of comparative analyses have been made and published (see Bulletins 373 and 439). The analyses mentioned have, however, been largely the work of a single analyst, and are subject to the "constant" and "personal" errors which are always possible where analyses are made by a single person. Some preliminary comparative counts by several analysts from different laboratories were made in the series of counts discussed by Conn; but these were preliminary in nature, and, because of the difficulties involved in continuing the work where the laboratories were so widely separated, the work was discontinued.

For these reasons, the authors of the present paper in 1915 drew up a plan of investigation under which a series of samples of milk were to be analysed in each of two laboratories maintained by the State, which were fortunately situated within 50 miles of each other. One of these was the laboratory maintained by the New York Agricultural Experiment Station at Geneva and the other that maintained by the Department of Dairy Industry of the State College of Agriculture at Ithaca. The associates and assistants in

---

[1] Breed R. S. and Brew, J. D. Counting bacteria by means of the microscope, N. Y. Agr. Exp. Sta., Tech. Bul. 49. 1916.

Brew, J. D. A comparison of the microscopical method and the plate method of counting bacteria in milk. N. Y. Agr. Exp. Sta., Bull. 373. 1914. (Out of print.)

Brew, J. D. and Dotterrer, W. D. The number of bacteria in milk. N. Y. Agr. Exp. Sta., Bul. 439. 1917.

these laboratories, named on the third page of this bulletin, entered into their part of the work with whole-hearted interest, and later brought the analytical work to a successful conclusion. A preliminary account of the results obtained has already been published.[1] Interruptions due largely to the world war have, however, prevented the earlier presentation of the final results and conclusions.

DESCRIPTION OF THE METHODS OF ANALYSIS USED

In considering the results secured, it should be kept in mind that the counting of bacteria in milk is an arithmetical problem which would be no more difficult than counting the number of beans in a bag, the number of trees in a wood, or the number of seeds in a bushel of mustard seed, if the bacteria could be seen and handled as readily as these objects. However, bacteria are such tiny things that they can be seen only with high magnification, and they may occur in such incredible numbers that comparisons with beans, trees or even mustard seeds give an inadequate idea of the difficulties involved.

Every one realizes the physical impossibility, or better, the impracticability of counting the trees on 100,000 acres of woodland. It is not only impracticable but physically impossible actually to count the bacteria in a quart of milk or even in a cubic centimeter of milk. In counting bacteria, as in counting trees, recourse must be had to the making of *estimates* of numbers, not actual *counts*. So-called bacterial "counts" are not counts in the strict sense of the word, and, like other estimates, their accuracy is largely dependent upon the care with which they are made. In order that the attention of the reader may be called to the fact, the word "count" has been placed in quotation marks thruout the body of the paper wherever it is used in the sense of an estimate.

Microscopic methods of counting bacteria.—The simplest method of counting objects is by direct observation. In the case of bacteria, this is obviously impossible because they are too small to be seen with the unaided eye. However, from the time when Leeuwenhoek (1683) first saw bacteria under his simple microscopes, microscopists have made more or less accurate estimates of the number of bacteria in various substances by direct observation under the microscope.

It is impossible to state who first made estimates of numbers of bacteria in milk by microscopic examination, but it is certain that no extensive use has been made of such methods until recently. (A detailed discussion of the historical development of these methods will be found in Technical Bulletin No. 49.)

Certain things prevent making the microscopic counts with absolute accuracy. These may be briefly summed up as follows:

[1] Breed, R. S. and Stocking, W. A. A preliminary report on a series of cooperative bacterial analyses of milk. *Jour. Dairy Sci.*, 1, 19–35. 1917.

a. There are certain optical limitations which make it difficult to prepare definite measured quantities of milk in such a way as to make all of the bacteria show with sufficient distinctness to permit counting under a microscope.

b. It is impossible to measure with absolute accuracy the exceedingly minute quantities of milk (1/500,000 to 1/300,000 cc.) which are the largest amounts that can be examined satisfactorily at any one time.

c. It is impossible to tell with certainty whether the bacteria seen under the microscope were actually living when the preparation was made.

d. Care must also be taken to prevent the growth and consequent increase in number of bacteria during the time consumed in preparing the material for microscopic examination, and to prevent the introduction of bacteria from extraneous sources.

Some of these difficulties can be partially, or even almost completely, overcome, but as a whole they can never be entirely eliminated by the most skillful analyst.

Agar plate methods of counting bacteria.—The second method of counting bacteria under consideration is fundamentally different from the first in that it involves inoculating some transparent nutrient jelly with measured quantities of milk containing bacteria. The nutrient jelly containing the bacteria is then incubated until the original bacteria have grown into masses of bacteria which are counted with a low power magnifying lens. These masses are usually termed "colonies" and it is these which are actually counted.

Such a method of counting may be compared to a method of counting seeds in which a measured quantity of seeds are germinated on a carefully prepared area of ground and the counts made from the plants which develop.

Historically, this method of counting bacteria is a direct outgrowth of the use of gelatin as a means of isolating pure cultures of bacteria first introduced by Koch[1] in 1881. In the milk work which has been so extensively developed in the United States, agar has supplanted gelatin as a culture medium, and the method of making counts has been standardized largely thru the efforts of members of the laboratory section of the American Public Health Association.[2] The first report issued by this association was published in 1910, and the second in 1916.

A modification of this technique, called the "little plate" method, has recently been developed and advocated for use by Frost.[3]

---

[1] Kock, Robert. Zur Untersuchung von pathogenen Organismen. *Mittheill. Kaiserl. Gesundheitsamte*, 1, 1–48. 1881.

[2] *Amer. Jour. Pub. Hyg.*, 20 (N. S. 6), 315–345. 1910.
Amer. Jour. Pub. Health, 6, 1315–1325. 1916.

[3] Frost, W. D. Rapid method of counting bacteria in milk. *Sci.*, 42, 255–256. 1915.

It differs from the technique ordinarily used in control laboratories in that the colonies which develop in agar are examined and counted under a compound microscope before they are visible to the unaided eye. Thus the time ordinarily consumed in waiting for the development of colonies is greatly shortened. In general, this technique has the same advantages as that possessed by the usual agar plate method, and is subject to the same general type of limitations.

These limitations upon the culture methods of counting bacteria are, as in the case of the limitations upon the microscopic technique, such that it is impossible to secure absolutely accurate counts. The chief difficulties may be summed up as follows and may be better understood if the comparison with the planting of seeds on prepared soil is kept in mind:

a. Only those bacteria grow which survive the necessary manipulations and are capable of growth into visible colonies under the conditions of aeration, food, moisture, temperature, etc., which are present. It is never certain that all of the bacteria originally living in the milk have grown and formed countable colonies on the plates.

b. Overcrowding of the colonies on the agar may prevent the development of some bacteria, or single bacterial colonies may grow so rapidly that all other colonies are repressed. The latter, so called "spreaders," are readily recognizable and their presence may be discounted. Likewise repression of colonies thru overcrowding is frequently recognizable.

c. A third difficulty is still more fundamental. It arises because the bacteria frequently exist in the milk in clumps of twos, threes, fours, or even as larger masses. Since these clumps cannot be perfectly separated into their component individuals by any known method of shaking or manipulation, the culture medium is always seeded with many groups of bacteria. As these grow they form a single mass, or colony, indistinguishable from colonies which have arisen from single individuals. Counts of colonies are therefore never comparable to counts of bacteria, except in those cases where the bacteria exist in the original milk as isolated individuals.

d. The introduction of extraneous bacteria and increase in number of bacteria after the samples are collected and before the culture medium is inoculated is always possible, even where carefully controlled. As additional colonies thus introduced cannot be detected from an examination of the plates, this always remains as a possible source of error.

e. Since it is impossible to get the best results where more than 300 colonies are grown on each plate, it becomes necessary to use minute quantities of milk (1/100,000 to 1/1,000,000 cc.) when accurate results are desired from samples giving " counts " in excess of 3,000,000 per cc. While this measurement is made by the dilution method (admittedly a very accurate method of measurement), yet inaccuracies of measurement are known to occur.

Skill and care may reduce many of these possible sources of error to a minimum, but, as a whole, they cannot be entirely eliminated.

Comparison between microscopic and agar plate methods of counting.— Since it is impossible to make counts of bacteria that are known to be absolutely accurate, it becomes very difficult to determine whether more accurate counts can be made by direct observation than by cultural methods or whether the opposite condition holds true. This being the case, it is evident that the common assumption that the agar plate method gives the more accurate results has no real basis upon which to rest.

One point of difference between the two methods should always be kept in mind in considering the accuracy of results. Because of the fact that estimates made from plate counts must be based on a count of colonies, which should not exceed 300 per plate, the amount of milk examined is largest where the bacteria are few in number and continually grows smaller as the number of bacteria increases. It is as if all scattered trees on 10,000 acres of cleared land could be counted, whereas in making estimates of a similar area of woodland only one tenth of an acre could be examined. Consequently it is probable that both the absolute accuracy and the percentage accuracy of plate counts are at their best in milk containing few bacteria, and that both the absolute and percentage accuracy of results decreases as the number of bacteria increases.

In contrast to this, microscopic counts are made from a small but fairly constant amount of milk regardless of the number of bacteria present. It is as if one acre plats from 100 different places selected at random could be examined in counting the trees upon 10,000 acre plats regardless of the number of trees present. Under these conditions, the percentage accuracy is at its best, and probably also the absolute accuracy, under intermediate conditions. Where there are few bacteria present, the percentage accuracy becomes poor tho, for practical purposes in grading milk, this is of little consequence because the absolute error is not large.[1] A failure to appreciate these differences in the two methods of counting has caused some unjustified criticism of microscopic counts.

PLAN OF THE PRESENT INVESTIGATION

The first work done was to analyze a series of twenty samples of fresh milk of a miscellaneous character (known in this bulletin as Series A). Counts were made from these both by the agar plate method and by direct microscopic examination. Chiefly because of

[1] The meaning of absolute and percentage accuracy as here used can be made clearer by a simple example. The percentage difference between 1,000 and 2,000 is the same as the percentage difference between 1,000,000 and 2,000,000; but the absolute difference in the first case (1,000) is much smaller than the absolute difference in the second case (1,000,000).

the inexperience of some of the analysts with microscopic counting, and because the miscellaneous character of the flora introduced so many possible sources of error that it was impossible to determine the exact cause of particular variations, the results obtained did not throw as much light on the question of the accuracy of the counts as had been expected.

On the other hand, the results from one of the samples which was known to contain a predominant colon flora were so instructive, that it was decided to use samples of this type for further work. A second series of samples (Series B) inoculated with the colon organism was therefore analysed on April 10, 1916, and later still (February 7, 1917), a third series (Series C) was examined. As the results obtained from Series B and C were instructive and explanatory of the results from Series A, the former series (B and C) are discussed first.

SERIES B.—SAMPLES INOCULATED WITH AN ORGANISM OF THE COLON GROUP

The advantage of the colon organism for the purpose in hand arises from the fact that it tends to live in milk as isolated individuals, only occasionally forming clumps of two, four or rarely more individuals. Likewise, it is always found evenly distributed thruout microscopic preparations of milk whenever it is present. It also grows well on ordinary media and at ordinary incubation temperatures. Thus "counts" carefully made from milk containing this organism may be expected to be nearly free from the sources of error discussed on pages 148 to 151.

In order to have a series of checks and counter checks upon the accuracy of the results, it was decided to use but three batches of milk, each batch to be analysed in triplicate by each analyst. The three batches were in each case prepared from a liter of a high grade, freshly-drawn milk known to contain very few bacteria. The first liter was inoculated with 2.5 cc. of an actively growing culture of an organism of the colon group, the second liter with 5 cc., and the third liter with 10 cc. of the same culture. Thus it was expected that the final "counts" would show ratios of approximately 1:2:4. From a rapid microscopic examination of the first liter of milk it was expected that the final "counts" from this milk would be between 100,000 and 500,000 per cc., and directions for making dilutions were given accordingly.

Ten samples, each containing about 15 cc. of milk, were sent to each of six analysts. No. 1 was a sample of the high grade fresh milk used as a base in preparing the inoculated milk. Nos. 2, 3, and 4 were samples from the liter of milk containing the smallest amount of the colon culture. Nos. 5, 6, and 7 were from the second liter of inoculated milk, while Nos. 8, 9, and 10 were from the liter of milk containing the largest number of colon organisms. This distribution

of samples resulted in eighteen separate analyses of each of the three liters of inoculated milk by two different methods — a total of 108 analyses. A further check on the final results was established by having all petri plates prepared in triplicate from each of two dilutions. The plates were recounted in each case by a second analyst in order that any carelessness in counting might be eliminated. Likewise, the microscopic preparations were made in duplicate from each sample, and they were also recounted by a second analyst. The six sets of samples were prepared at Geneva at 7 A. M., were thoroly iced, and three sets forwarded by messenger to Ithaca. The analytical work was started in both laboratories about 10 A. M., and the petri plates and microscopic slides were prepared in all cases before noon. In one respect the samples used in this series were not perfect, as later examination showed that masses of bacteria, which did not break apart readily, had formed in the thin film of cream on the skim milk culture. Consequently, occasional groups of 10, 20 or more individuals were found in the final microscopic preparations.

In this series of analyses, one set of samples was used by a seventh analyst at Geneva for making "counts" by a dilution technique. In making these, one cc. quantities of suitable dilutions were added to sterile milk tubes in triplicate. These inoculated tubes were then incubated for three days at 37° C., and examined for growth. As these "counts" were made by only a single person, and gave but a rough idea of the number of organisms present, they are not included in the present report. The results were in general accord with the results secured by the agar plate and the microscopic methods, and are mentioned because they give confirmatory evidence that the final average "counts" obtained from this series of analyses were actually nearly accurate.

Altho it makes an extended series of tables, it has been felt to be important to give the detailed results secured from counting each agar plate and each microscopic slide together with estimates of numbers computed from these. This permits anyone to study the variations observed, and allows mathematical slips to be detected. Likewise to facilitate comparisons between the results secured by the two different methods, standard deviations and coefficients of variability have been computed for the "counts" or estimates of numbers per cc. as reported for each sample: but no further mathematical analysis of the data has been made.

a. AGAR PLATE COUNTS

Technique used.—The analysts were instructed to prepare dilutions as follows: Sample No. 1—1:10 and 1:100; Samples Nos. 2, 3, and 4—1:1,000 and 1:10,000; Samples Nos. 5 to 10—1:10,000 and 1:100,000. These were made by using freshly prepared and accu-

rately measured 9 and 99 cc. water blanks. One cc. pipettes were used by all analysts, but those used at Ithaca were of the type with two graduation marks, while those used at Geneva were of the type with a single graduation mark. As the latter were supposed to have been calibrated to *deliver* 1 cc. quantities, Analysts B and D merely emptied them carefully in each case as used, and did not rinse them by drawing the dilution water into the pipette.

All analysts were supplied from a single lot of agar (1 per cent Difco peptone, 1 per cent lactose, 0.3 per cent Liebig's beef extract, 1.5 per cent air dried agar) prepared at the Ithaca laboratory. The acidity of this agar, before adjusting, was 1.6 per cent normal to phenolphthalein, and by the addition of NaOH it was reduced to 1.1 per cent. No record of the H-ion concentration was made.

Incubation temperatures were not definitely controlled in all cases, but they were between 25° and 30° C. Plates were counted at the end of three days when the colonies were well developed. Troublesome spreaders were practically absent, and recounts of the colonies on the plates were in all cases in close accord with the first counts.

The "counts" for Samples Nos. 2, 3, and 4, as reported here, were secured by averaging the counts from the individual plates from both dilutions; while the counts from the 1:100,000 dilutions were usually discarded for the remaining samples, as they ordinarily showed less than 20 colonies per plate.

Counts obtained.—The figures given in Tables I-VI show not only the counts from the individual plates, but also the estimated numbers per cc. as computed from these. The results from Samples Nos. 2, 3, and 4; from Samples Nos. 5, 6, and 7; and from Samples Nos. 8, 9, and 10 were averaged separately and were used as a basis for computing the ratios given at the foot of each table. If the samples had been correctly inoculated and the estimates of numbers were made perfectly, the ratios would have been 1 : 2 : 4 in each case.

A study of the results obtained will show that these are very regular, as one would expect if the analytical work were carefully done. In order that the reader may readily find the extreme variations, the maximum and minimum "counts" are retabulated in Table XXI, columns 2 and 3. The final average "counts" have been collected in Table XIX. Standard deviations and coefficients of variability have been computed (Table XX) for each of the three groups of colon-inoculated samples.

The coefficients of variability were found to range from 7.7 for Samples Nos. 2, 3, and 4 to 13.8 for Samples Nos. 5, 6, and 7 with an average coefficient of variability of 11.1.

TABLE I.— SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst B. Counted by Analysts B and D.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "counts."
1	B	1 : 10	111	121	70	1,010	
	D	1 : 10	71	63	35	560	785
2	B	1 : 1000	325	336	275		
	B	1 : 10000	32	34	41	334,000	
	D	1 : 1000	326	350	259		
	D	1 : 10000	33	36	42	341,000	324,000
3	B	1 : 1000	326	300	Spr.		(Analyst B)
	B	1 : 10000	Spr.	Spr.	31	312,000	325,000
	D	1 : 1000	328	309	Spr.		(Analyst D)
	D	1 : 10000	Spr.	Spr.	32	319,000	Ave. 325,000
4	B	1 : 1000	312	300	Spr.		
	B	1 : 10000	36	33	33	326,000	
	D	1 : 1000	304	295	Spr.		
	D	1 : 10000	33	33	32	316,000	
5	B	1 : 10000	56	61	Spr.	585,000	550,000
	D	1 : 10000	56	63	Spr.	595,000	(Analyst B)
6	B	1 : 10000	44	54	38	453,000	567,000
	D	1 : 10000	44	56	36	453,000	(Analyst D)
7	B	1 : 10000	65	63	56	613,000	Ave. 558,000
	D	1 : 10000	70	67	59	653,000	
8	B	1 : 10000	116	114	111		
	B	1 : 100000	11	14	12	1,185,000	1,393,000
	D	1 : 10000	121	114	107		(Analyst B)
	D	1 : 100000	12	14	12	1,203,000	1,427,000
9	B	1 : 10000	133	146	169	1,493,000	(Analyst D)
	D	1 : 10000	130	156	175	1,537,000	Ave. 1,410.000
10	B	1 : 10000	152	153	145	1,500,000	
	D	1 : 10000	157	158	147	1,540,000	

Ratio 1 : 1.70 : 4.30 for B's counts. Ave. ratio 1 : 1.72 : 4.34.
1 : 1.74 : 4.39 for D's counts.

TABLE II.—SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst C. Counted by Analysts C and B.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "counts."
1	C	1 : 10	25	28	29	273	
	B	1 : 10	57	Plates lost		570	421
2	C	1 : 10000	42	35	40	390,000	
	B	1 : 10000	38	33	55	420,000	382,000
3	C	1 : 1000	310	320	320		(Analyst C)
	C	1 : 10000	40	50	40	375,000	367,000
	B	1 : 1000	367	310	300		(Analyst B)
	B	1 : 10000	36	?	?	334,000	Ave. 375,000
4	C	1 : 10000	42	46	26	380,000	
	B	1 : 10000	40	41	23	347,000	
5	C	1 : 10000	70	66	Contam-	680,000	657,000
	B	1 : 10000	68	63	inated	655,000	(Analyst C)
6	C	1 : 10000	98	65	65	760,000	644,000
	B	1 : 10000	104	66	63	777,000	(Analyst B)
7	C	1 : 10000	46	58	55	530,000	Ave. 650,000
	B	1 : 10000	45	53	52	500,000	
8	C	1 : 10000	125	105	120	1,170,000	1,190,000
	B	1 : 10000	130	102	115	1,160,000	(Analyst C)
9	C	1 : 10000	113	118	125	1,190,000	1,150,000
	B	1 : 10000	113	113	112	1,130,000	(Analyst B)
10	C	1 : 10000	115	118	130	1,210,000	Ave. 1,170,000
	B	1 : 10000	109	116	124	1,160,000	

Ratio 1 : 1.72 : 3.12 for C's counts. Ave. ratio 1 : 1.74 : 3.13.
1 : 1.76 : 3.13 for B's counts.

TABLE III.— SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst D. Counted by Analysts D and C.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "counts."
1	D	1 : 10	36	26	34	320	
	C	1 : 10	28	29	Spr.	285	303
2	D	1 : 1000	295	319	312		
	D	1 : 10000	26	27	35	301,000	
	C	1 : 1000	290	290	315		
	C	1 : 10000	26	25	40	301,000	313,000
3	D	1 : 1000	319	311	294		(Analyst D)
	D	1 : 10000	42	33	29	327,000	333,000
	C	1 : 1000	Not counted				(Analyst C)
	C	1 : 10000	42	33	32	357,000	Ave. 323,000
4	D	1 : 1000	321	297	294		
	D	1 : 10000	35	30	30	310,000	
	C	1 : 1000	Not counted				
	C	1 : 10000	42	30	30	340,000	
5	D	1 : 10000	61	57	57	583,000	614,000
	C	1 : 10000	62	55	55	573,000	(Analyst D)
6	D	1 : 10000	64	72	72	693,000	590,000
	C	1 : 10000	63	66	70	663,000	(Analyst C)
7	D	1 : 10000	66	52	52	567,000	Ave. 602,000
	C	1 : 10000	60	52	48	533,000	
8	D	1 : 10000	117	120	117	1,180,000	1,230,000
	C	1 : 10000	115	118	108	1,140,000	(Analyst D)
9	D	1 : 10000	132	122	119	1,240,000	1,180,000
	C	1 : 10000	128	116	112	1,190,000	(Analyst C)
10	D	1 : 10000	136	126	120	1,270,000	Ave. 1,205,000
	C	1 : 10000	124	118	120	1,210,000	

Ratio 1 : 1.96 : 3.93 for D's counts. Ave. ratio 1 : 1.87 : 3.74.
1 : 1.77 : 3.54 for C's counts.

TABLE IV.—SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst F. Counted by Analysts F and I.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "counts."
1	F	1 : 10	Spr.	27	24	255	
	I	1 : 10	Spr.	32	26	290	273
2	F	1 : 1000	314	394	372		
	F	1 : 10000	31	43	38	367,000	
	I	1 : 1000	301	351	337		
	I	1 : 10000	31	43	39	353,000	
3	F	1 : 1000	401	378	373		387,000
	F	1 : 10000	47	43	36	402,000	(Analyst F)
	I	1 : 1000	372	346	348		369,000
	I	1 : 10000	45	44	39	391,000	(Analyst I)
4	F	1 : 1000	365	377	449		Ave. 378,000
	F	1 : 10000	36	38	42	392,000	
	I	1 : 1000	323	324	344		
	I	1 : 10000	36	40	42	362,000	
5	F	1 : 10000	57	55	63	583,000	
	I	1 : 10000	69	57	63	630,000	616,000
6	F	1 : 10000	80	68	66	713,000	(Analyst F)
	I	1 : 10000	72	64	65	670,000	626,000
7	F	1 : 10000	55	59	52	553,000	(Analyst I)
	I	1 : 10000	53	61	59	577,000	Ave. 621,000
8	F	1 : 10000	143	159	159	1,537,000	
	I	1 : 10000	141	162	148	1,503,000	1,571,000
9	F	1 : 10000	134	151	177	1,540,000	(Analyst F)
	I	1 : 10000	126	159	152	1,457,000	1,530,000
10	F	1 : 10000	148	158	185	1,637,000	(Analyst I)
	I	1 : 10000	161	150	178	1,630,000	Ave. 1,551,000

Ratio 1 : 1.59 : 4.06 for F's counts. Ave. ratio 1 : 1.64 : 4.11.
1 : 1.69 : 4.15 for I's counts.

TABLE V.—SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst H. Counted by Analysts H and F.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "counts."
1	H	1 : 10	Spr.	45	23	340	
	F	1 : 10	Spr.	46	26	360	350
2	H	1 : 1000	300	322	302		
	H	1 : 10000	27	38	38	326,000	
	F	1 : 1000	344	372	345		
	F	1 : 10000	27	37	33	339,000	
3	H	1 : 1000	290	280	307		329,000
	H	1 : 10000	38	35	35	326,000	(Analyst H)
	F	1 : 1000	312	331	342		332,000
	F	1 : 10000	33	32	35	331,000	(Analyst F)
4	H	1 : 1000	290	286	326		Ave. 330,000
	H	1 : 10000	30	41	40	335,000	
	F	1 : 1000	302	283	348		
	F	1 : 10000	27	37	38	326,000	
5	H	1 : 10000	52	58	70	600,000	
	F	1 : 10000	54	57	65	587,000	668,000
6	H	1 : 10000	71	55	76	673,000	(Analyst H)
	F	1 : 10000	63	Spr.	68	655,000	648,000
7	H	1 : 10000	77	84	58	730,000	(Analyst F)
	F	1 : 10000	69	82	60	703,000	Ave. 658,000
8	H	1 : 10000	153	142	140	1,450,000	
	F	1 : 10000	153	147	174	1,580,000	1,418,000
9	H	1 : 10000	129	137	142	1,360,000	(Analyst H)
	F	1 : 10000	164	142	129	1,450,000	1,563,000
10	H	1 : 10000	142	131	160	1,443,000	(Analyst F)
	F	1 : 10000	155	158	185	1,660,000	Ave. 1,491,000

Ratio 1 : 2.03 : 4.31 for H's counts. Ave. ratio 1 : 1.99 : 4.51.
1 : 1.95 : 4.71 for F's counts.

TABLE VI.—SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst I. Counted by Analysts I and H.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "counts."
1	I	1 : 10	21	23	22	220	
	H	1 : 10	13	24	20	190	205
2	I	1 : 1000	379	347	328		
	I	1 : 10000	36	33	31	342,000	
	H	1 : 1000	344	379	342		
	H	1 : 10000	38	34	31	349,000	
3	I	1 : 1000	344	356	379		360,000
	I	1 : 10000	34	47	33	370,000	(Analyst I)
	H	1 : 1000	297	341	350		334,000
	H	1 : 10000	34	46	32	351,000	(Analyst H)
4	I	1 : 1000	389	365	363		Ave. 347,000
	I	1 : 10000	37	39	33	368,000	
	H	1 : 1000	380	260	280		
	H	1 : 10000	41	22	27	303,000	
5	I	1 : 10000	78	88	71	790,000	
	H	1 : 10000	79	86	59	747,000	757,000
6	I	1 : 10000	80	66	68	713,000	(Analyst I)
	H	1 : 10000	85	64	73	740,000	751,000
7	I	1 : 10000	83	82	65	767,000	(Analyst H)
	H	1 : 10000	84	78	68	767,000	Ave. 754,000
8	I	1 : 10000	154	120	146	1,400,000	
	H	1 : 10000	148	126	149	1,410,000	1,460,000
9	I	1 : 10000	144	145	153	1,470,000	(Analyst I)
	H	1 : 10000	145	135	150	1,430,000	1,480,000
10	I	1 : 10000	137	168	148	1,510,000	(Analyst H)
	H	1 : 10000	170	160	152	1,610,000	Ave. 1,470,000

Ratio 1 : 2.10 : 4.06 for I's counts. Ave. ratio 1 : 2.17 : 4.25.
1 : 2.25 : 4.43 for H's counts.

The tabulation of results revealed a tendency on the part of the Geneva men (B, C, and D) to report lower "counts" than those reported from Ithaca, a tendency which had been previously noted in Series A. Thus in Series B, only nine out of 27 "counts" from the Geneva laboratory were higher than the final averages, while 20 out of 27 "counts" from the Ithaca laboratory were higher than the average figures.

As the differences were relatively small, and as one of the Geneva men (C) who rinsed his pipettes obtained higher counts than the others, a suspicion arose that they were caused by inaccuracies in the measurements of the milk and of the dilution waters. Consequently, the one cc. pipettes used were recalibrated, whereupon it was found that the use of the one mark pipettes without rinsing in the dilution waters was causing a small but detectable loss as they were calibrated to *contain* one cc. and did not *deliver* the full amount.

In order to test the matter further, the Geneva analysts used the same pipettes for the next series of analyses, carefully rinsing each pipette as used. Likewise, in order to secure more accurate dilutions, 1 : 10 dilutions were prepared for each sample by withdrawing 5 cc. of milk with a 5 cc. pipette, and adding this to 45 cc. of sterile water. Subsequent dilutions were prepared with one cc. pipettes. The results secured with this improved system of measurement are discussed on page 187.

The ratios between the final average "counts" made by each analyst, as shown at the bottom of Tables I to VI, agree well with the expected ratio of 1 : 2 : 4. It is worth noting, however, that, in all but one of the six triple ratios, the first ratio is less than the 1: 2 ratio which was expected. As the average ratio between the first and last "counts" was almost exactly 1: 4, this condition raises the question whether the second liter of milk may not have failed actually to receive the full number of bacteria that were supposed to have been added. The final average ratio (see Table XX) for all of the plate "counts" was 1: 1.85: 4.00.

The regularity of the plate "counts" and the agreement between the observed and the expected ratios make it probable that the figures given by the analysts were actually accurate estimates of the number of bacteria present. Yet it must be remembered, as already explained (page 146), that both of these things might be true in the case of agar plate "counts" which were actually very inaccurate.

All of the analysts agreed that Sample No. 1 contained very few bacteria, the agar plate "counts" being less than 800 per cc. in all cases. The final average "count" was 390 per cc. The results show that this milk contained so few bacteria that the number present could not have influenced the final figures as reported for the remain-

ing samples in the series. This sample is discussed further in connection with Series A (pages 225, 229, et al.).

b. MICROSCOPIC COUNTS.

Counts of two kinds were made by microscopic examination of the stained dried milk. The first of these, spoken of in this paper as the "group" count, was obtained by regarding each isolated organism and each actual clump of two or more organisms as single "groups." From theoretical considerations it was expected that the estimate based on this count would be lower than the agar plate "counts" as the latter are based on the growth of the "groups" after they are partially broken apart in the preparation of the dilution waters.

A count of individual bacteria was also made, any organism showing clear indication of approaching division being recorded as two individuals. It was expected that the estimate based on this count would in all cases be larger than the agar plate "count."

All analysts examined 100 fields of the oil immersion lens on each of two duplicate preparations from each sample, and nearly all recorded not only the number of bacteria seen, but also the number of twos, threes, fours, etc. Analysts A, B, and D, who were more experienced in the technique than the others, used special ocular micrometers (see Technical Bulletin No. 49) ruled in circles and quadrants of circles, and adjusted the tube length of their microscopes so that the dried solids from 1/600,000 cc. of milk were visible in each microscopic area counted. As only the central part of the field was used, the definition was clear and sharp and the danger of overlooking bacteria was lessened. Each of the three analysts mentioned examined 200 fields for each sample of milk, so that each counted the bacteria in 1/3,000 cc. regardless of the number present.

The less experienced men used the entire field of the microscope and did not adjust their instruments so that it was necessary for them to use an irregular number in their computations. In all cases they examined a larger amount of milk than did the experienced men, but their counts were, nevertheless, decidedly less regular than those returned by the experienced men.

This fact was so evident from the "counts" returned that the maximum microscopic "counts" obtained by the men experienced in microscopic counting have been retabulated in Table XXII for comparison with the maximum and minimum "counts" reported by all analysts as given in Table XXI. In comparing the two tables it will be seen that, whereas the maximum "counts" given in Table XXI for Samples Nos. 2, 3, and 4 are greater than the minimum "counts" given for Samples Nos. 5, 6, and 7, and the maximum "counts" for the latter group of samples are greater than the minimum "counts" for Samples Nos. 8, 9, and 10, no such overlapping of "counts" occurs in the results given in Table XXII.

TABLE VII.— SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.
Microscopic preparations made and counted by Analyst B.

Sample no.	Groups of 1	2	3	4	5	6	7	8	9	10	11	12	14	18	30	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	2	1	....	....	....	....	....	....	....	....	....	....	....	....	....	18,000	24,000	....	....
		1	....	....	....	....	....	....	....	....	....	....	....	....	....	6,000	12,000	12,000	18,000
*2	45	23	3	5	2	....	....	1	....	....	....	....	....	....	....	234,000	414,000	....	....
																240,000	414,000	237,000	414,000
*3	35	35	2	3	3	1	....	1	....	....	1	....	1	....	....	246,000	540,000	....	....
																246,000	522,000	246,000	531,000
*4	56	35	1	5	1	1	....	....	....	1	....	....	1	....	....	342,000	570,000	....	....
																264,000	534,000	303,000	552,000
*5	95	52	4	5	2	1	....	....	....	2	....	1	1	....	....	522,000	900,000	....	....
																456,000	858,000	489,000	879,000
*6	108	70	8	7	1	2	....	1	....	....	....	....	....	....	1	492,000	942,000	....	....
																696,000	1,188,000	594,000	1,065,000
7	63	43	5	1	....	1	....	....	....	1	....	....	....	....	....	684,000	1,104,000	....	....
	39	29	1	5	4	3	....	1	....	2	....	....	....	....	....	504,000	1,116,000	594,000	1,110,000
8	89	55	5	6	....	1	1	....	....	1	....	1	....	....	....	954,000	1,638,000	....	....
	76	74	5	3	1	1	....	....	1	1	....	1	....	....	....	978,000	1,758,000	966,000	1,698,000
9	125	70	7	8	1	3	2	....	....	....	....	....	1	....	....	1,302,000	2,214,000	....	....
	118	55	7	8	....	1	....	....	1	....	....	....	....	....	....	1,140,000	1,776,000	1,221,000	1,995,000
10	109	71	4	5	....	3	....	1	....	....	....	....	....	....	....	1,158,000	1,854,000	....	....
	110	71	8	8	....	3	....	2	1	1	....	....	....	1	....	1,230,000	2,274,000	1,194,000	2,064,000
Totals 2 to 10	1,068	683	60	69	15	21	3	7	3	9	1	3	4	1	1				

* Duplicate microscopic preparations were made for all samples; but the records kept did not show the number seen on each preparation for Samples 2, 3, 4, 5, 6.

Ratio 1:2.13:4.30 for the group "counts." 1:2.04:3.85 for the individual "counts."

TABLE VIII.—SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst B. Counted by Analyst D.

Sample no.	Groups of 1	2	3	4	5	6	7	8	9	10	12	13	17	18	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Less than 6,000	Less than 6,000	...	...
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Less than 6,000	Less than 6,000	Less than 3,000	Less than 3,000
2	33	15	...	3	...	1	...	...	1	...	...	...	...	...	318,000	540,000	...	...
	28	15	1	...	1	1	1	...	1	...	...	...	1	...	294,000	630,000	306,000	585,000
3	32	12	2	1	...	...	...	...	...	...	...	...	...	...	282,000	396,000	...	...
	37	11	3	...	1	...	...	...	...	...	...	...	...	...	312,000	438,000	297,000	417,000
4	29	17	4	1	...	...	...	...	...	...	...	...	...	...	306,000	474,000	...	...
	32	15	2	2	...	...	...	...	...	...	...	...	...	...	306,000	456,000	306,000	465,000
5	59	34	5	2	...	1	...	...	...	...	...	...	...	...	606,000	936,000	...	...
	65	36	4	2	...	...	1	...	...	...	...	...	...	...	648,000	984,000	627,000	960,000
6	58	37	3	1	...	...	2	...	...	...	...	...	...	...	606,000	954,000	...	...
	54	39	3	3	...	1	...	...	...	...	...	...	...	...	600,000	954,000	603,000	954,000
7	55	40	...	...	...	1	...	...	...	...	...	...	...	...	576,000	846,000	...	...
	50	43	6	1	4	...	...	...	...	...	1	...	...	...	630,000	1,140,000	603,000	993,000
8	118	71	9	4	3	...	1	1	...	...	...	...	...	...	1,242,000	1,998,000	...	...
	117	63	5	5	4	1	2	1	1	2	...	1	...	...	1,212,000	2,208,000	1,227,000	2,103,000
9	109	68	8	3	...	...	...	...	1	...	...	1	...	...	1,140,000	1,818,000	...	...
	132	58	5	4	2	1	1	...	1	...	...	...	1	...	1,230,000	1,968,000	1,185,000	1,893,000
10	123	67	5	4	1	1	...	...	...	...	...	...	...	1	1,212,000	1,902,000	...	...
	103	80	5	5	3	2	...	...	...	...	...	...	...	...	1,188,000	1,950,000	1,200,000	1,926,000
Totals 2 to 10	1,234	721	70	41	19	10	8	2	5	2	1	2	2	1				

Ratio 1:2.02:3.97 for the group "counts." 1:1.98:4.04 for the individual "counts."

TABLE IX.— SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst C. Counted by Analyst A.

Sample no.	Groups of 1	2	3	4	5	6	7	8	9	11	12	16	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	....	....	....	....	....	....	....	....	....	....	....	....	Less than 6,000	Less than 6,000	....	....
	....	....	....	....	....	....	....	....	....	....	....	....	Less than 6,000	Less than 6,000	Less than 3,000	Less than 3,000
2	27	11	2	1	....	....	....	....	1	....	....	....	252,000	408,000	....	....
	38	12	....	....	....	....	1	....	....	....	....	....	306,000	414,000	279,000	411,000
3	20	14	1	3	1	1	....	....	....	....	....	....	240,000	444,000	....	....
	32	15	2	1	....	....	1	....	....	1	....	....	312,000	540,000	276,000	492,000
4	36	14	1	....	....	....	....	....	....	1	....	....	312,000	468,000	....	....
	31	4	1	1	1	....	....	....	....	....	....	....	228,000	306,000	270,000	387,000
5	60	24	2	....	3	....	....	....	....	....	2	....	546,000	918,000	....	....
	57	31	4	1	....	2	....	....	1	....	....	....	576,000	936,000	561,000	927,000
6	44	22	3	3	....	....	1	....	....	....	....	....	438,000	696,000	....	....
	62	26	4	....	....	1	....	1	....	....	....	....	564,000	840,000	501,000	768,000
7	54	27	4	1	....	....	....	....	....	....	1	....	522,000	816,000	....	....
	76	25	4	2	1	....	....	....	....	....	....	....	648,000	906,000	585,000	861,000
8	110	57	6	6	3	....	....	....	....	....	....	....	1,092,000	1,686,000	....	....
	117	49	13	4	1	....	1	1	1	....	....	....	1,122,000	1,794,000	1,107,000	1,740,000
9	134	49	6	1	1	2	1	....	1	1	....	....	1,176,000	1,788,000	....	....
	116	53	8	3	2	....	....	....	....	....	....	....	1,092,000	1,608,000	1,134,000	1,698,000
10	106	42	4	1	2	....	....	2	1	....	....	....	948,000	1,446,000	....	....
	106	57	3	6	2	1	2	....	....	....	....	1	1,068,000	1,794,000	1,008,000	1,620,000
Totals 2 to 10	1,226	532	68	34	17	7	7	4	5	3	3	1				

Ratio 1:2.00:3.94 for the group "counts." 1:1.98:3.92 for the individual "counts."

TABLE X.— SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INNOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst C. Counted by Analyst B.

Sample no.	Groups of										No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	1	2	3	4	5	6	8	10	12	18				
1	....	....	....	....	....	....	....	....	....	....	Less than 6,000	Less than 6,000	....	....
	....	....	....	....	....	....	....	....	....	....	Less. than 6,000	Less than 6,000	Less than 3,000	Less than 3,000
2	14	20	....	2	....	1	....	....	....	....	222,000	408,000	....	....
	22	20	3	1	....	....	1	....	....	....	282,000	498,000	252,000	453,000
3	11	12	....	1	....	1	....	....	....	....	150,000	270,000	....	....
	11	12	2	3	1	....	1	....	....	....	180,000	396,000	165,000	333,000
4	14	11	....	3	....	....	1	....	....	....	174,000	336,000	....	....
	23	12	2	....	....	....	....	1	....	....	228,000	378,000	201,000	357,000
5	32	28	....	4	....	2	....	....	....	....	396,000	696,000	....	....
	37	27	7	....	....	....	1	....	....	1	438,000	828,000	417,000	762,000
6	36	18	2	4	....	....	1	....	1	1	378,000	792,000	....	....
	31	18	3	....	....	1	....	....	....	....	318,000	492,000	348,000	642,000
7	47	30	2	2	1	1	....	....	....	....	498,000	792,000	....	....
	51	33	4	5	....	1	....	....	....	....	564,000	930,000	531,000	861,000
8	71	53	3	7	....	2	....	2	....	....	828,000	1,476,000	....	....
	95	56	7	5	1	1	....	....	....	....	990,000	1,554,000	909,000	1,515,000
9	58	54	5	8	2	....	....	....	....	....	762,000	1,338,000	....	....
	76	64	6	5	1	1	....	....	....	....	918,000	1,518,000	840,000	1,428,000
10	81	70	3	6	....	2	....	....	1	....	978,000	1,668,000	....	....
	72	49	7	7	1	....	....	....	....	....	816,000	1,344,000	897,000	1,506,000
Totals 2 to 10	782	587	56	63	7	13	5	3	2	2				

Ratio 1:2.10:4.28 for the group "counts." 1:1.98:3.89 for the individual "counts."

TABLE XI.— SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made and counted by Analyst D.

Sample no.	Groups of 1	2	3	4	5	6	7	8	9	10	11	12	14	16	19	100	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals
1	1																6,000	6,000		
																	000	000	3,000	3,000
2	29	13	2														264,000	366,000		
	25	23	1														294,000	444,000	279,000	405,000
3	39	19															348,000	462,000		
	31	13	2	1													282,000	402,000	315,000	432,000
4	28	11	2	3			1										270,000	450,000		
	30	12	1	3	1		1										288,000	486,000	279,000	468,000
5	61	33									1						570,000	828,000		
	53	27	6														516,000	750,000	543,000	789,000
6	68	31	2	1													612,000	840,000		
	65	34	1		1	1											612,000	882,000	612,000	861,000
7	70	33	2	2		2	2	1									672,000	1,104,000		
	80	37	12	5	4		2	1			1					1	858,000	2,178,000	765,000	1,641,000
8	166	98	10	5	2						1		1				1,698,000	2,682,000		
	151	89	8	6		1	1		1					1			1,548,000	2,490,000	1,623,000	2,586,000
9	143	97	9	5		1		1	1	1		1	1				1,560,000	2,658,000		
	148	80	7	4	5	1	2				2						1,494,000	2,472,000	1,527,000	2,565,000
10	127	61	7	7	2	4			1						1		1,260,000	2,160,000		
	146	85	12	7	1	1	1										1,518,000	2,388,000	1,389,000	2,274,000
Totals 2 to 10	1,460	796	84	49	16	11	10	3	3	1	5	1	2	1	1	1				

Ratio 1:2.20:5.20 for the group "counts." 1:2.52:5.70 for the individual "counts."

TABLE XII.— SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst D. Counted by Analyst A.

Sample no.	Groups of 1	2	3	4	5	6	7	8	9	10	13	15	24	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	1	....	....	....	....	....	....	....	....	....	....	....	....	6,000	6,000	....	....
	....	....	....	....	....	....	....	....	....	....	....	....	....	000	000	3,000	3,000
2	20	8	1	....	....	....	....	....	....	....	....	....	....	174,000	234,000	....	....
	24	9	....	....	1	....	....	....	....	....	....	....	....	204,000	282,000	189,000	258,000
3	30	9	1	1	....	1	....	....	2	....	....	....	....	264,000	474,000	....	....
	23	8	2	2	1	1	....	....	....	....	....	1	....	228,000	474,000	246,000	474,000
	28	22	....	....	....	2	....	....	....	....	....	....	....	312,000	504,000	....	....
4	16	12	....	2	....	....	....	....	....	....	....	....	....	180,000	288,000	246,000	396,000
5	59	19	3	2	1	....	1	....	....	1	....	....	....	516,000	816,000	....	....
	48	17	4	....	2	....	....	....	....	....	....	....	....	426,000	624,000	471,000	720,000
6	57	29	2	....	....	....	....	....	....	....	....	....	....	528,000	726,000	....	....
	74	28	4	2	....	....	....	....	....	....	....	....	....	648,000	900,000	588,000	813,000
7	56	18	4	3	....	....	....	....	1	1	1	....	....	504,000	888,000	....	....
	57	23	2	2	2	2	....	....	....	....	....	....	....	528,000	834,000	516,000	861,000
8	135	60	3	1	1	....	1	1	....	....	....	....	....	1,212,000	1,728,000	....	....
	109	54	10	3	1	....	....	....	....	....	....	....	....	1,062,000	1,584,000	1,137,000	1,656,000
9	143	61	6	2	2	....	....	....	....	....	....	....	....	1,284,000	1,806,000	....	....
	125	51	6	4	....	2	....	....	....	....	....	....	....	1,128,000	1,638,000	1,206,000	1,722,000
10	110	56	3	1	3	....	....	....	....	....	....	....	1	1,044,000	1,644,000	....	....
	145	55	5	4	....	....	....	....	1	....	1	....	....	1,266,000	1,848,000	1,155,000	1,746,000
Totals 2 to 10	1,259	539	56	29	14	8	2	1	4	2	2	1	1				

Ratio 1:2.31:5.14 for the group "counts." 1:2.12:4.54 for the individual "counts."

TABLE XIII.— SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.
Microscopic preparations made and counted by Analyst F.

Sample no.	Groups of																	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	*1	2	3	4	5	6	7	9	10	12	13	15	16	17	19	24	26				
1	?	10																362,000	412,000		
	?	4		1														154,000	188,000	258,000	300,000
2	?	16	1															273,000	377,000		
	?	14																293,000	362,000	283,000	370,000
3	?	20	2		1													412,000	531,000		
	?	28																502,000	641,000	457,000	586,000
4	?	6	2															154,000	203,000		
	?	5																169,000	193,000	162,000	198,000
5	?	30	9	3		1		1										815,000	1,202,000		
	?	22	1	2			1				1	1						502,000	820,000	659,000	1,011,000
6	?	32	3		1	1		1	1									695,000	1,063,000		
	?	25	5										1		1			665,000	1,038,000	680,000	1,050,000
7	?	13	1															303,000	377,000		
	?	19		1														288,000	397,000	295,000	387,000
8	?	41	3	2	1													864,000	1,128,000		
	?	45	7	4	3				1							1		744,000	1,416,000	804,000	1,272,000
9	?	47	3		4	1	1											909,000	1,292,000		
	?	48	6	2	2	1	1		1					1			1	874,000	2,728,000	891,000	2,010,000
10	?	34	8	2	1													596,000	883,000		
	?	50	4			1	1		1	1								944,000	1,391,000	770,000	1,137,000
Totals† 2 to 10	?	495	55	16	13	5	4	2	4	1	1	1	1	1	1	1	1				

* No record was kept of the number of ones seen; and apparently not all of the groups larger than this were recorded.
† Not directly comparable with totals previously given.
Ratio 1: 1.81: 2.73 for the group "count." 1: 2.12: 3.83 for the individual "count."

TABLE XIV.—SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst F. Counted by Analyst I.

Sample no.	*Groups of											No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	1	2	3	4	5	6	7	8	9	11	13				
1	31	6	....	....	....	....	....	....	....	....	....	263,000	305,000	....	....
	3	4	....	....	....	....	....	....	....	....	....	50,000	78,000	156,000	192,000
2	36	13	....	....	....	....	....	....	....	....	....	348,000	440,000	....	....
	27	22	....	....	....	....	....	....	....	....	....	348,000	504,000	348,000	472,000
3	20	12	....	....	....	....	....	....	....	....	....	227,000	312,000	....	....
	42	11	1	....	1	....	....	....	....	....	....	390,000	511,000	309,000	412,000
4†	22	8	....	....	....	....	....	....	....	....	....	213,000	270,000	....	....
	30	8	....	....	....	....	....	....	....	....	....	788,000	2,393,000	500,000	1,332,000
5	82	22	1	....	....	....	....	....	....	....	....	745,000	916,000	....	....
	77	22	1	....	....	1	1	....	....	....	....	731,000	1,001,000	738,000	958,000
6	47	12	2	....	....	....	1	....	....	....	....	440,000	592,000	....	....
	80	19	....	....	....	....	....	....	....	....	....	703,000	838,000	572,000	715,000
7	24	9	1	....	2	....	....	1	....	....	....	263,000	447,000	....	....
	45	14	3	....	1	....	....	....	....	1	....	454,000	753,000	359,000	600,000
8	87	24	1	1	1	....	....	....	1	....	....	817,000	1,108,000	....	....
	133	41	1	2	1	1	....	....	....	....	....	1,271,000	1,683,000	1,044,000	1,396,000
9	127	33	1	....	2	....	....	....	....	....	....	1,157,000	1,462,000	....	....
	107	47	....	1	1	1	....	....	....	....	1	1,115,000	1,626,000	1,136,000	1,544,000
10	121	64	....	....	....	....	....	....	....	....	....	1,086,000	1,314,000	....	....
	136	35	2	1	....	1	....	....	1	....	....	1,249,000	1,640,000	1,168,000	1,477,000

* As the amount of milk examined in each field of the microscope was not recorded, the number of groups found cannot be compared with those previously given. No totals are given for this reason.

† In second preparation, 1 field with 140 individuals and 11 groups; 1 field with 148 individuals and 60 groups.

Ratio 1:1.44: 2.92 for the group "count." 1:1.03:1.99 for the individual "count."

Table XV.— Series B. Analyses of Samples of Fresh Milk Inoculated with the Colon Organism.

Microscopic preparations made and counted by Analyst H.

Sample no.	*Groups of								No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	1	2	3	4	5	6	7	10				
1	12	6	...	...	...	...	...	...	94,000	119,000	75,000	92,000
	9	2	...	...	...	...	...	...	55,000	65,000	...	...
2	?	8	...	...	...	...	...	...	259,000	298,000	...	...
	?	7	...	1	...	...	...	...	263,000	318,000	261,000	308,000
3	?	10	1	...	...	...	...	...	159,000	219,000	...	...
	?	21	2	1	...	...	...	...	288,000	422,000	224,000	321,000
4	?	10	2	...	...	...	...	...	174,000	268,000	...	...
	?	2	...	...	...	...	...	...	119,000	129,000	147,000	199,000
5	?	7	3	3	1	2	...	...	268,000	447,000	...	...
	...	...	...	(not counted)		...	...	...	...	...	268,000	447,000
6	?	23	2	4	1	...	1	...	417,000	716,000	...	...
	?	19	4	7	...	...	...	...	457,000	716,000	437,000	716,000
7	?	13	4	2	1	...	...	1	527,000	750,000	...	...
	?	?	?	?	?	?	...	...	?	626,000	527,000	688,000
8	?	14	3	2	...	1	...	...	378,000	522,000	...	...
	?	20	4	1	...	1	...	...	572,000	790,000	475,000	656,000
9	?	28	5	2	1	1	2	...	770,000	1,098,000	...	...
	?	35	1	2	...	2	...	...	229,000	989,000	500,000	1,044,000
10	?	37	1	3	...	1	...	1	477,000	1,039,000	...	...
	?	35	5	4	2	1	...	...	974,000	1,372,000	726,000	1,206,000

* As the records are incomplete and the amount of milk examined in each field was not recorded, no totals are given.

Ratio 1:1.95:2.69 for the group "count." 1:2.24:3.51 for the individual "count."

TABLE XVI.—SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst H. Counted by Analyst F.

Sample no.	*Groups of													No. of groups per cc.	No. of individuals per cc.	Ave. no. groups	Ave. no. individuals.
	1	2	3	4	5	6	7	8	10	11	12	14	20				
1	?	4												109,000	129,000		
	?	2												74,000	84,000	92,000	107,000
2	?	7	2				2				1	1		328,000	561,000		
	?	7		2										268,000	332,000	298,000	447,000
3	?	12	1		1				1					248,000	327,000		
	?	6	1											203,000	243,000	226,000	285,000
4	?	14			1									184,000	273,000		
	?	6												94,000	124,000	139,000	199,000
5	?	10	1	1										273,000	348,000		
			(not counted)													273,000	348,000
6	?	37	3	4	1	2								531,000	879,000		
	?	41	2	3	2	1								661,000	994,000	596,000	937,000
7	?	27	5					1						536,000	770,000		
	?	32	3	1	2	1				1				566,000	874,000	551,000	822,000
8	?	76	4	1		1	2							1,292,000	1,809,000		
	?	69	7					1	1					1,128,000	1,615,000	1,210,000	1,712,000
9	?	34	5				1							934,000	1,227,000		
	?	52	5	3		3			1		1		1	999,000	1,610,000	966,000	1,419,000
10	?	50	5	5	1	2		1			1			795,000	1,327,000		
	?	63	12	2				1	1					944,000	1,471,000	870,000	1,399,000

* As the records are incomplete no totals are given.

Ratio 1:2.14:4.59 for the group "count." 1:2.26:4.87 for the individual "count."

TABLE XVII.— SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.
Microscopic preparations made and counted by Analyst I.

Sample no.	*Groups of															No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	1	2	3	4	5	6	7	8	10	11	15	17	33	77	150				
1	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...	28,000	36,000	...	...
	6	2	...	...	...	...	...	...	...	...	...	...	...	...	...	57,000	71,000	42,000	53,000
2	19	10	...	...	...	...	...	...	...	...	...	...	...	...	...	206,000	277,000	...	...
	35	10	2	...	...	...	...	...	...	...	...	...	...	...	...	334,000	433,000	270,000	355,000
3	20	19	2	...	...	...	...	...	1	1	1	...	1	1	1	334,000	2,556,000	...	...
	31	32	2	...	...	1	1	...	...	...	...	1	...	...	...	583,000	940,000	459,000	1,748,000
4	6	10	...	1	...	...	...	...	...	...	...	...	...	...	...	121,000	213,000	...	...
	19	6	...	...	...	...	...	...	...	...	...	...	...	...	...	178,000	220,000	149,000	217,000
5	72	20	...	1	2	...	...	...	...	1	...	...	...	...	...	682,000	973,000	...	...
	84	35	1	...	1	1	...	...	...	...	...	...	...	...	...	866,000	1,193,000	774,000	1,083,000
6	52	35	1	...	1	...	...	...	...	...	...	...	...	...	...	618,000	923,000	...	...
	38	15	1	...	4	...	1	...	...	...	...	...	...	...	...	419,000	696,000	518,000	810,000
7	50	20	...	...	...	...	...	...	...	...	...	...	...	...	...	497,000	639,000	...	...
	56	19	2	2	...	...	...	...	...	...	...	...	...	...	...	575,000	767,000	536,000	703,000
8	100	40	2	...	...	...	...	...	...	...	...	...	...	...	...	1,008,000	1,321,000	...	...
	109	37	3	...	...	...	...	...	...	...	...	...	...	...	...	1,015,000	1,363,000	1,012,000	1,342,000
9	72	30	1	1	1	...	...	...	...	...	...	...	...	...	...	738,000	1,022,000	...	...
	83	32	1	1	1	1	...	...	...	...	...	...	...	...	...	845,000	1,171,000	792,000	1,096,000
10	69	54	2	...	4	...	...	...	...	...	...	...	...	...	...	916,000	1,441,000	...	...
	97	18	1	...	1	...	...	1	...	...	...	...	...	...	...	845,000	1,065,000	880,000	1,253,000

* As the amount of milk examined in each field was not recorded no totals are given.

Ratio 1:2.08:3.05 for the group "count." 1:1.12:1.59 for the individual "count."

TABLE XVIII.—SERIES B. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst I. Counted by Analyst H.

Sample no.	*Groups of														No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	1	2	3	4	5	6	7	8	9	10	14	15	20	75				
1	?	1	....	....	....	....	....	....	....	....	....	....	....	....	30,000	35,000	....	....
	?	....	....	....	....	....	....	....	....	....	....	....	....	....	20,000	20,000	25,000	28,000
2	?	3	....	1	....	....	1	....	....	....	....	....	....	....	45,000	104,000	....	....
	?	4	1	1	....	....	....	....	....	....	....	....	....	....	45,000	89,000	45,000	97,000
**3	?	8	2	2	1	....	1	1	....	1	....	....	....	....	343,000	2,226,000	....	....
	?	8	....	....	2	....	....	....	....	1	....	1	....	....	253,000	1,456,000	298,000	1,841,000
4	?	3	1	....	....	....	....	....	....	....	....	....	....	....	75,000	104,000	....	....
	?	4	2	....	....	....	....	....	....	....	....	....	....	....	119,000	159,000	97,000	131,000
5	?	23	3	2	....	....	2	....	....	....	....	....	....	....	472,000	750,000	....	....
	?	26	1	2	1	1	1	....	1	....	1	....	....	1	542,000	1,312,000	507,000	1,031,000
6	?	15	2	....	3	....	....	....	....	....	....	....	....	....	273,000	442,000	....	....
	?	3	....	1	1	....	....	....	....	....	....	....	....	....	99,000	174,000	186,000	308,000
7	?	4	1	1	....	....	....	....	....	....	....	....	....	....	60,000	104,000	....	....
	?	3	2	1	....	....	....	....	....	....	....	....	....	....	84,000	293,000	72,000	199,000
8	?	34	4	1	1	1	....	1	....	....	....	....	....	....	850,000	1,158,000	....	....
	?	36	6	5	....	....	2	....	....	....	....	....	....	....	914,000	1,317,000	882,000	1,238,000
9	?	30	1	4	1	....	1	....	....	....	....	....	....	....	592,000	860,000	....	....
	?	30	2	5	....	....	....	1	....	1	....	....	....	....	547,000	865,000	570,000	863,000
10	?	13	3	4	1	....	1	....	....	....	....	....	....	....	417,000	616,000	....	....
	?	17	4	5	....	....	1	1	....	....	....	....	1	....	452,000	875,000	435,000	746,000

* As the records are incomplete and the amount of milk examined in each field was not recorded no totals are given.

** Also one group of 25, one of 39, one of 65, and one of 200 in the first preparation. Two groups of 50 and one of 85 in the second preparation.

Ratio 1:1.74:4.21 for the group "counts." 1:0.50:0.92 for the individual "counts."

This fact is brought out thus prominently because some have failed to appreciate that accurate microscopic counting requires the same training in attention to details that is required in making agar plates, and have condemned the technique because inexperienced workers have failed to secure regular and consistent results. In the case under discussion, it should be remembered that the least experienced of the men were trained laboratory workers with some previous training in microscopic counting, and they probably did better work than would the ordinary beginner with the technique.

Tables VII to XVII give a record not only of the final group and individual "counts," but also of the number of isolated bacteria, number of pairs, threes, fours, etc., seen by each analyst. This record permits detailed comparisons to be made between the work of the different men. Thus the reason or reasons for some of the wider discrepancies may be found.

Computations of the standard deviations are given in Table XXI with their coefficients of variability. From this table it will be seen that the coefficients of variability of the group "counts" vary from 21.3 for the group of samples containing the largest number of bacteria to 26.8 for the group of samples containing the fewest bacteria. The average for all samples was 24.1.

The coefficients of variability for the individual "counts" were larger (as was to be expected) and varied from 24.0 for the group of samples having the largest number of bacteria to 33.6 for the group of samples containing the fewest bacteria. The average for all samples was 28.3.

In spite of the variability of the microscopic "counts," the irregularities counterbalanced each other in such a way that the final average ratios, as given in Table XXI, are very close to the expected ratio of 1:2:4. Thus, for the group "counts" the observed ratio was 1: 1.98: 3.85, while that for the "counts" of individual bacteria was 1: 1.69: 3.26. It will be observed that all of these ratios are lower than the expected ratios. As there are several possible explanations for this condition, it is useless to speculate upon them.

Some fairly wide variations from the expected ratio will be found among the ratios actually obtained by the individual analysts which are recorded at the bottom of Tables VII to XVII. However, many of the ratios obtained agree well with the expected ratio.

It should also be pointed out in connection with these "counts" (as has been done with the plate "counts") that neither agreement in results nor the fact that the observed and the expected ratios are in close agreement prove that the "counts" as given are truly accurate. These conditions raise a strong probability that the final average figures are very close approximations to the actual number of groups or of bacteria present per cc., but they do not *prove* the accuracy of the results.

C. COMPARISON BETWEEN THE PLATE AND THE MICROSCOPIC COUNTS

It is not until the results obtained by the two different methods of counting are compared with each other that the probable accuracy of the counts can be established with reasonable certainty. An examination of the results as given in Table XIX shows that the final average group "counts" are invariably lower than the final average plate "counts," while the final average individual "counts" are higher than either of the other counts. This is as it should be if the results were truly accurate, for it is to be expected that the groups were somewhat broken up in the process of preparing the plates, thereby causing more colonies to appear on the plates than there were groups originally present in the milk. However, it is not to be expected that all groups were broken into their component individuals, so that the plate "count" should never be as large as the individual "count" if both were truly accurate.

Even the average "counts" as reported by each individual analyst (see Table XIX) usually show a plate "count" intermediate between the two microscopic "counts." As is to be expected, however, this relationship is not as perfectly maintained as it is in the case of the final average "counts." Thus, in eight cases out of a possible 54, the plate "counts" reported were less than the group "counts" as reported, while, in 17 cases out of a possible 54, the plate "counts" exceeded the individual "counts." Altho this analytical work was done with care, it is evident that errors in "counts" were not absolutely eliminated.

The test for accuracy just discussed is a relatively severe one, for it must be remembered that the milk used for analysis contained very small groups of bacteria (average size 1.6 individuals). This means that the individual "count" is only 1.6 times the size of the group "count" if both are perfectly made, so that large variations in the plate "counts" would cause these to be larger or smaller than the microscopic "counts." Since the conditions found indicate that all three counts represent fairly accurately the conditions as they exist, it then becomes possible, by a comparison between the group and the plate "counts," to determine how much the clumps were broken apart by the shaking in the dilution waters. Thus we find that, whereas the average group in the original milk from which Samples Nos. 2, 3, and 4 were prepared, contained 1.85 individuals, the average group in the final dilution water contained but 1.39 individuals. In the case of Samples Nos. 5, 6, and 7 the average size of the group was reduced from 1.58 to 1.27 by the shaking and dilution process; while in Samples Nos. 8, 9, and 10 the average size of the groups was reduced from 1.58 to 1.13 individuals.

One of the most interesting comparisons which can be made between the three types of counts is that of their coefficients of

TABLE XIX.— SERIES B. SUMMARY OF PLATE AND MICROSCOPIC "COUNTS."

Sample no.	Analyst†	Plate "count." Combined average.‡	Analyst†	Group "count." Average for each analyst.	Group "count." Combined average.	Individual "count." Average for each analyst.	Individual "count." Combined average.
*1		390			3,000		4,000
2-4	BB	325,000	BB	§262,000	282,000	§499,000	494,000
	BD		BD	303,000		489,000	
	CC	375,000	CA	275,000	241,000	430,000	405,000
	CB		CB	206,000		381,000	
	DD	323,000	DD	291,000	259,000	435,000	405,000
	DC		DA	227,000		376,000	
	FF	378,000	FF	301,000	343,000	385,000	562,000
	FI		FI	386,000		739,000	
	HH	330,000	HH	211,000	216,000	276,000	293,000
	HF		HF	221,000		310,000	
	II	347,000	II	293,000	220,000	773,000	731,000
	IH		IH	147,000		690,000	
Final ave.—		346,000			260,000		482,000
5-7	BB	558,000	BB	§559,000	585,000	§1,018,000	993,000
	BD		BD	611,000		969,000	
	CC	650,000	CA	549,000	490,000	852,000	803,000
	CB		CB	432,000		755,000	
	DD	602,000	DD	640,000	582,000	1,097,000	948,000
	DC		DA	525,000		798,000	
	FF	621,000	FF	545,000	550,000	816,000	787,000
	FL		FI	556,000		758,000	
	HH	658,000	HH	411,000	442,000	617,000	660,000
	HF		HF	473,000		702,000	
	II	754,000	II	609,000	432,000	865,000	689,000
	IH		IH	255,000		513,000	
Final ave. —		640,000			514,000		813,000
8-10	BB	1,410,000	BB	§1,127,000	1,165,000	§1,919,000	1,946,000
	BD		BD	1,204,000		1,974,000	
	CC	1,170,000	CA	1,083,000	982,000	1,686,000	1,584,000
	CB		CB	882,000		1,483,000	
	DD	1,205,000	DD	1,513,000	1,339,000	2,475,000	2,091,000
	DC		DA	1,166,000		1,708,000	
	FF	1,551,000	FF	822,000	969,000	1,473,000	1,472,000
	FI		FI	1,116,000		1,472,000	
	HH	1,491,000	HH	567,000	791,000	969,000	1,240,000
	HF		HF	1,015,000		1,510,000	
	II	1,470,000	II	895,000	762,000	1,230,000	1,090,000
	IH		IH	629,000		949,000	
Final ave.—		1,383,000			1,001,000		1,570,000

* Detailed results for Sample 1 are given in Table LXIV, page 225.
† The first analyst named made the plates or slides. The second counted them.
‡ The individual averages will be found in Tables I to VI, pages 155 to 160.
§ As Analysts A, B, and D examined 1 cu. mm. of milk in making their "counts," the exact number of groups, or of bacteria that they saw is obtained by dividing their results by 1000. The remaining analysts examined a little more than 1 cu. mm.

variability. By examining these in Table XX, it will be seen that the average coefficient of variability for all of the plate "counts" in Series B was 11.1. On the other hand, the similar value for the group "count" is 24.1 and for the individual "count" it is 28.3.[1]

TABLE XX.— SERIES B. SUMMARY OF TABLE XIX.

Sample No.	Plate "count."			Group "count."			Individual "count."		
	Final averages.	Standard deviation.	Coefficient variation.	Final averages.	Standard deviation.	Coefficient variation.	Final averages.	Standard deviation.	Coefficient variation.
2-4	346,000	26,600	7.7	260,000	69,700	26.8	482,000	136,000	33.6
5-7	640,000	88,300	13.8	514,000	124,000	24.1	813,000	221,000	27.2
8-10	1,383,000	163,000	11.8	1,001,000	213,000	21.3	1,570,000	377,000	24.0
Ave..	....		11.1	....		24.1	....		28.3
	Ratio 1 :1 :85 :4.00 1.00 :2.16			Ratio 1 :1.98 :3.85 1.00 :1.95			Ratio 1 :1.69 :3.28 1.00 :1.93		

Average number of bacteria per group — 1.6 individuals.

This shows at once that the microscopic "counts" were more variable than were the plate "counts," a fact which is evident even on a casual inspection. There are certain things which should be kept in mind, however, in comparing these coefficients of variability, namely, that such variations may be produced by the limitations in the technique itself, by differences in the skill of the analysts, or by actual differences in the number of bacteria or groups of bacteria present in the quantities of milk examined by the different analysts.

The greater variability of the individual "counts" as contrasted with the group "counts" is, for example, due to the fact that it is always affected by one more source of variation than is the group count, namely differences in the number of individuals found in the groups. As both the group "counts" and the individual "counts" were made from identical portions of the original samples of milk, the greater variability of the latter "counts" is caused by the fact that some analysts chanced to find larger sized groups than did others.

[1] Unfortunately the 18 "counts" obtained from each set of samples have not been given in the tables, but they may be obtained by simple computation from the figures given in Tables I-VI, fourth column, and Tables VII-XVIII last two columns. In the case of the plate "counts," each pair of adjoining figures should be averaged; in the case of the microscopic "counts," the figures from adjoining tables should be averaged in pairs.

TABLE XXI.—SERIES B. MAXIMUM AND MINIMUM PLATE AND MICROSCOPIC "COUNTS."

Sample no.	Plate "counts."		Group "counts."		Individual "counts."		Total no. "counts."
	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	
1........	190	1,010	000	258,000	000	300,000	12
	220	570	000	156,000	000	192,000	....
2-4......	301,000	420,000	45,000	500,000	97,000	1,841,000	36
	301,000	402,000	97,000	459,000	131,000	1,748,000	....
5-7......	453,000	790,000	72,000	774,000	199,000	1,641,000	36
	453,000	777,000	186,000	765,000	308,000	1,110,000	....
8-10.....	1,130,000	1,660,000	435,000	1,623,000	656,000	2,586,000	36
	1,140,000	1,637,000	475,000	1,527,000	746,000	2,565,000	....

TABLE XXII.—SERIES B. MAXIMUM AND MINIMUM MICROSCOPIC "COUNTS" OBTAINED BY THE ANALYSTS EXPERIENCED IN THIS TECHNIQUE.

Sample no.	Group "count."		Individual "count."		Total no. "counts."
	Minimum.	Maximum.	Minimum.	Maximum.	
1...........	000	12,000	000	18,000	6
	000	3,000	000	3,000	....
2-4..........	165,000	315,000	258,000	585,000	18
	189,000	303,000	333,000	552,000	....
5-7..........	348,000	765,000	642,000	1,641,000	18
	417,000	627,000	720,000	1,110,000	....
8-10.........	840,000	1,623,000	1,506,000	2,586,000	18
	897,000	1,527,000	1,428,000	2,565,000	....

SERIES C.—SAMPLES INOCULATED WITH AN ORGANISM OF THE COLON GROUP

As all of the analysts felt that the accuracy of the work thus far done could be still further improved as a result of the experience gained, it was decided to duplicate the last series of analyses, introducing such improvements in technique as had been suggested by the results secured. Circumstances, however, prevented its repetition until February 7, 1917, at which time only four of the analysts who had participated in the work of both Series A and B were available. The group of six was therefore completed by including one man who had participated in the work of Series A only, and one man who had participated in the work of Series B only.

Each analyst knew the general nature of the samples furnished, and knew something of the results as they were obtained in the laboratory in which he worked; but no comparisons were made between the "counts" as obtained in the two laboratories until the

final reports were ready. These conditions were permitted as the work of every analyst was checked by a second analyst, and every man was keenly interested in finding the true state of affairs regardless of any preconceived ideas.

Six sets of samples were prepared at the Geneva laboratory. Three of the sets were sent to Ithaca by messenger as before, and three retained at Geneva. Sample No. 1 was taken from a high grade fresh milk which was used as the base for the inoculated samples. In preparing the three liters of inoculated milk for sampling, the procedure followed was to add enough of the colon culture to a liter of milk to give a count in excess of 1,000,000 per cc. as determined roughly by immediate microscopic examination. Then 500 cc. of this milk was diluted with 500 cc. of the uninoculated fresh milk to make a second liter of milk which presumably contained exactly one half of the organisms present in the first liter. Then 500 cc. was taken from the second liter, and added to another 500 cc. portion of the uninoculated milk, making a third liter of milk which presumably contained one half of the organisms from the second liter, or one fourth of the organisms from the first liter.

Samples Nos. 2, 3, and 4 were prepared from the third liter of milk; Samples Nos. 5, 6, and 7 from the second liter; and Samples Nos. 8, 9, and 10 from the first liter. Thus, the final average "counts" from these three groups of samples were expected to show the ratio of 1:2:4 as before.

a. AGAR PLATE COUNTS

Technique used.— All of the agar used was prepared in a single batch at Ithaca and it had the same composition as before. The acidity of the medium was approximately 1 per cent normal acid to phenolphthalein, and was found to have a reaction of about pH:7.6.

As already stated (page 161) the Geneva analysts were instructed to rinse all one cc. pipettes as they were used, and all analysts prepared their first dilutions by adding 5 cc. of milk to 45 cc. of sterile water. Instructions were given to use 1:10 and 1:100 dilutions for Sample No. 1; 1:1,000 and 1:10,000 dilutions for Samples Nos. 2, 3, and 4; and 1:10,000 and 1:100,000 dilutions for the remaining samples. Later it became evident that these instructions were satisfactory as plates were secured in each case which developed more than 30, and less than 300, colonies. The plates were recounted by a second analyst from the laboratory in which the plates were prepared.

Counts obtained.— The detailed results are given in Tables XXIII to XXVIII. From these it will be seen that the high grade milk was again found to have a very low "count," the final average plate "count" (see Table XLI) being 623 per cc. Thus it was sufficiently free from bacteria to serve satisfactorily as a base for the inoculated samples. The detailed results from this sample are retabulated in Table LXV, and are discussed in connection with Series A (see page 229).

. . . .

TABLE XXIII.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst B. Counted by Analysts B and C.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "counts."
1	B	1 : 10	55	48	55	530	
	C	1 : 10	70	50	55	580	560
2	B	1 : 10000	99	78	85	873,000	884,000
	C	1 : 10000	95	85	Spr.	900,000	(Analyst B)
3	B	1 : 10000	97	85	86	893,000	885,000
	C	1 : 10000	95	82	88	883,000	(Analyst C)
4	B	1 : 10000	85	103	78	887,000	Ave. 885,000
	C	1 : 10000	82	100	80	873,000	
5	B	1 : 10000	144	168	173	1,620,000	1,630,000
	C	1 : 10000	145	160	162	1,560,000	(Analyst B)
6	B	1 : 10000	165	147	180	1,640,000	1,580,000
	C	1 : 10000	160	148	175	1,610,000	(Analyst C)
7	B	1 : 10000?	70	61	54	*617,000	Ave. 1,605,000
	C	1 : 10000?	68	72	63	*677,000	
8	B	1 : 100000	42	34	28	3,470,000	3,570,000
	C	1 : 100000	46	35	30	3,700,000	(Analyst B)
9	B	1 : 100000	41	35	42	3,930,000	3,630,000
	C	1 : 100000	38	35	42	3,830,000	(Analyst C)
10	B	1 : 100000	32	34	33	3,300,000	Ave. 3,600,000
	C	1 : 100000	33	38	30	3,370,000	

* Omitted from the final averages as it is probable that the dilutions were incorrectly prepared.

Ratio 1 : 1.84 : 4.04 for B's counts. Ave. ratio 1 : 1.72 : 4.34.
1 : 1.79 : 4.10 for C's counts.

TABLE XXIV.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst C. Counted by Analysts C and E.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "counts."
1	C	1 : 10	105	110	100	1,050	
	E	1 : 10	100	99	103	1,010	1,030
2	C	1 : 10000	68	72	76	720,000	783,000
	E	1 : 10000	59	73	79	703,000	(Analyst C)
3	C	1 : 10000	78	90	65	777,000	784,000
	E	1 : 10000	71	87	Broken	790,000	(Analyst E)
4	C	1 : 10000	88	78	90	853,000	Ave. 784,000
	E	1 : 10000	85	81	91	860,000	
5	C	1 : 10000	145	155	155	1,520,000	1,470,000
	E	1 : 10000	141	154	172	1,560,000	(Analyst C)
6	C	1 : 10000	155	152	135	1,470,000	1,470,000
	E	1 : 10000	152	159	131	1,470,000	(Analyst E)
7	C	1 : 10000	135	152	140	1,420,000	Ave. 1,470,000
	E	1 : 10000	136	142	137	1,380,000	
8	C	1 : 100000	33	42	34	3,630,000	3,650,000
	E	1 : 100000	35	45	33	3,770,000	(Analyst C)
9	C	1 : 10000	300	290	Spr.	2,950,000	3,770,000
	E	1 : 10000	347	329	272	3,160,000	(Analyst E)
10	C	1 : 100000	45	41	45	4,370,000	Ave. 3,710,000
	E	1 : 100000	41	39	51	4,370,000	

Ratio 1 : 1.88 : 4.66 for C's counts. Ave. ratio 1 : 1.88 : 4.73.
1 : 1.87 : 4.79 for E's counts.

TABLE XXV.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst E. Counted by Analysts E and B.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "counts."
1	E	1 : 10	57	68	62	620	
	B	1 : 10	51	67	60	590	605
2	E	1 : 10000	82	68	87	790,000	771,000
	B	1 : 10000	79	67	79	750,000	(Analyst E)
3	E	1 : 10000	82	69	80	770,000	738,000
	B	1 : 10000	78	67	78	743,000	(Analyst B)
4	E	1 : 10000	68	76	84	760,000	Ave. 755,000
	B	1 : 10000	67	73	76	720,000	
5	E	1 : 10000	153	162	169	1,610,000	1,640,000
	B	1 : 10000	152	160	166	1,590,000	(Analyst E)
6	E	1 : 10000	194	177	173	1,810,000	1,600,000
	B	1 : 10000	187	173	171	1,770,000	(Analyst B)
7	E	1 : 10000	149	142	155	1,490,000	Ave. 1,620,000
	B	1 : 10000	146	141	149	1,450,000	
8	E	1 : 10000	386	391	373	3,830,000	3,710,000
	B	1 : 10000	359	380	356	3,650,000	(Analyst E)
9	E	1 : 100000	32	34	41	3,600,000	3,650,000
	B	1 : 100000	32	34	41	3,600,000	(Analyst B)
10	E	1 : 100000	26	46	40	3,700,000	Ave. 3,680,000
	B	1 : 100000	27	44	39	3,700,000	

Ratio 1 : 2.13 : 4.81 for E's counts. Ave. ratio 1 : 2.15 : 4.87.
1 : 2.17 : 4.94 for B's counts.

TABLE XXVI.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst F. Counted by Analysts F and H.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "count."
1	F	1 : 10	45	56	54	520	
	H	1 : 10	41	42	52	450	485
2	F	1 : 10000	82	84	83	830,000	827,000
	H	1 : 10000	84	84	89	857,000	(Analyst F)
3	F	1 : 10000	103	77	81	870,000	857,000
	H	1 : 10000	109	79	79	890,000	(Analyst H)
4	F	1 : 10000	83	76	75	780,000	Ave. 842,000
	H	1 : 10000	91	80	76	823,000	
5	F	1 : 10000	171	184	205	1,870,000	1,840,000
	H	1 : 10000	163	162	175	1,670,000	(Analyst F)
6	F	1 : 10000	181	207	165	1,840,000	1,590,000
	H	1 : 10000	145	176	134	1,520,000	(Analyst H)
7	F	1 : 10000	186	164	194	1,810,000	Ave. 1,715,000
	H	1 : 10000	166	143	161	1,570,000	
8	F	1 : 10000	342	336	332		
	F	1 : 100000	40	55	44	*4,000,000	
	H	1 : 10000	304	352	312	*4,210,000	
	H	1 : 100000	42	54	60		
9	F	1 : 10000	390	359	416		3,650,000
	F	1 : 100000	30	39	36	*3,690,000	(Analyst F)
	H	1 : 10000	354	343	324	*3,420,000	3,590,000
	H	1 : 100000	31	39	33		(Analyst H)
10	F	1 : 10000	350	328	343		Ave. 3,620,000
	F	1 : 100000	39	23	31	*3,250,000	
	H	1 : 10000	303	318	336	*3,130,000	
	H	1 : 100000	40	19	33		

*Averages include counts from both 1 : 10000 and 1 : 100000 dilutions.

Ratio 1 : 2.22 : 4.41 for F's counts. Ave. ratio 1 : 2.04 : 4.30.
1 : 1.86 : 4.19 for H's counts.

TABLE XXVII.—SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst H. Counted by Analysts H and I.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "count."
1	H	1 : 10	60	49	61	567	
	I	1 : 10	61	46	62	563	564
2	H	1 : 10000	65	81	68	713,000	803,000
	I	1 : 10000	72	89	68	763,000	(Analyst H)
3	H	1 : 10000	98	86	58	807,000	857,000
	I	1 : 10000	105	89	67	870,000	(Analyst I)
4	H	1 : 10000	66	108	93	890,000	Ave. 830,000
	I	1 : 10000	73.	112	96	937,000	
5	H	1 : 10000	178	137	149	1,550,000	1,600,000
	I	1 : 10000	168	146	146	1,530,000	(Analyst H)
6	H	1 : 10000	181	161	181	1,740,000	1,620,000
	I	1 : 10000	177	173	190	1,800,000	(Analyst I)
7	H	1 : 10000	151	157	145	1,510,000	Ave. 1,610,000
	I	1 : 10000	150	159	150	1,530,000	
8	H	1 : 10000	289	Spr.	322		
	H	1 : 100000	30	38	39	*3,360,000	
	I	1 : 10000	337	361	349	*3,580,000	
	I	1 : 100000	29	39	42		
9	H	1 : 10000	347	317	350		3,300,000
	H	1 : 100000	37	34	30	*3,370,000	(Analyst H)
	I	1 : 10000	360	325	344	*3,360,000	3,380,000
	I	1 : 100000	37	34	28		(Analyst I)
10	H	1 : 100000	299	317	327		Ave. 3,340,000
	H	1 : 100000	41	28	26	*3,160,000	
	I	1 : 10000	314	329	328	*3,200,000	
	I	1 : 100000	39	32	24		

*Averages include counts from both 1 : 10000 and 1 : 100000 dilutions.

Ratio 1 : 1.99 : 4.11 for H's counts. Ave. ratio 1 : 1.94 : 4.02.
1 : 1.89 : 3.94 for I's counts.

TABLE XXVIII.—SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Petri plates prepared by Analyst I. Counted by Analysts I and F.

Sample no.	Analyst.	Dilution.	No. colonies on the individual plates.			"Count" per cc.	Average "count."
1	I	1 : 10	48	49	51	493	
	F	1 : 10	49	53	50	500	496
2	I	1 : 10000	94	100	76	900,000	850,000
	F	1 : 10000	71	89	78	793,000	(Analyst I)
3	I	1 : 10000	76	94	81	836,000	803,000
	F	1 : 10000	69	92	82	810,000	(Analyst F)
4	I	1 : 10000	83	90	71	813,000	Ave. 827,000
	F	1 : 10000	85	91	66	806,000	
5	I	1 : 10000	147	156	173	1,590,000	1,720,000
	F	1 : 10000	147	149	166	1,540,000	(Analyst I)
6	I	1 : 10000	159	207	171	1,790,000	1,620,000
	F	1 : 10000	150	185	158	1,640,000	(Analyst F)
7	I	1 : 10000	151	193	191	1,780,000	Ave. 1,670,000
	F	1 : 10000	149	191	161	1,670,000	
8	I	1 : 10000	369	412	340		
	I	1 : 100000	38	37	35	*3,700,000	
	F	1 : 10000	337	374	336	*3,660,000	
	F	1 : 100000	41	39	35		
9	I	1 : 10000	496	492	429		3,910,000
	I	1 : 100000	45	42	47	*4,600,000	(Analyst I)
	F	1 : 10000	484	446	Spr.	*4,520,000	3,870,000
	F	1 : 100000	44	44	Spr.		(Analyst F)
10	I	1 : 10000	295	311	322		Ave. 3,890,000
	I	1 : 100000	44	33	36	*3,430,000	
	F	1 : 10000	276	308	317	*3,420,000	
	F	1 : 100000	43	33	39		

*Averages include counts from both 1 : 10000 and 1 : 100000 dilutions.

Ratio 1 : 2.02 : 4.60 for I's counts. Ave. ratio 1 : 2.02 : 4.71.
1 : 2.02 : 4.82 for F's counts.

The inoculated milk gave higher "counts" than before, the final average plate "count" from Samples Nos. 2, 3, and 4 being 821,000 per cc. as contrasted with 346,000 per cc. for the similar group of samples from Series B. With the single exception of the "count" obtained by Analyst B for Sample No. 7 (see Table XXIII), the plate "counts" are in close agreement. In the instance mentioned, the number of colonies which developed on the plates was much less than developed on the plates made from the duplicate samples by the same analyst, and likewise fewer than the number which developed on the plates made by the other analysts. As the duplicate plates from this one irregular sample agreed with each other, it was concluded that Analyst B had inadvertently used a 99 cc. water blank in place of a 9 cc. blank in preparing the original dilutions. If no other results had been at hand for comparison, the error would have remained undetected.

Only minor and insignificant differences appeared in the recounts of colonies from the agar plates.

The tendency of the Geneva analysts to return a majority of the counts which were below the average was practically eliminated, as they returned but 15 out of a possible 26 counts which were lower than the average (see summary of Table No. XLI). On the other hand, the Ithaca analysts returned 12 out of a possible 27 counts which were lower than the average. This improved condition was probably associated with the rinsing of the one mark pipettes and the greater care taken in securing accurate measurements in making the dilutions.

The final average ratio between the plate "counts" was 1:1.97:4.43. This is neither decidedly better nor worse than the similar ratio of 1:1.85:4.00 obtained in Series B. The differences between the observed and expected ratios are small in both cases. Even the ratios as computed for the individual analysts (see foot of Tables XXIII-XXVIII) are free from gross discrepancies. All agreed in reporting that Samples Nos. 8, 9, and 10 contained more than four times the number of organisms found in Samples Nos. 2, 3, and 4, making it probable that this was actually the case. In every instance, the ratio between the "counts" for Samples Nos. 2, 3, and 4 and for Samples Nos. 5, 6, and 7 was very close to the expected ratio of 1:2.

As before, the maximum and minimum "counts" have been collected in a separate table (Table XLIII). A mere inspection of these in comparison with the similar results from Series B (Table XXI) shows the results from Series C to be even more regular than those previously obtained. This fact becomes more evident from the computed standard deviations and their corresponding coefficients of variability which are recorded in Table XLII. From this table, it will be seen that the coefficient of variation for both the first and second groups of samples in Series C was only 7.1. The similar

value for the third group was 10.6, making an average coefficient of variability of only 8.3. This is even better than the average of 11.1 obtained in Series B, and indicates that the improved technique and experience of the analysts resulted in "counts" which were even more regular and, therefore, presumably more accurate than before.

b. MICROSCOPIC COUNTS

However, the most striking change in the character of the "counts" obtained from Series C, as contrasted with Series B, occurred in the microscopic "counts." As before, both group and individual "counts" were made. These are given in detail in Tables XXIX to XL.

Slides were prepared in duplicate from each sample, and all were recounted by a second analyst. As the slides were exchanged between the laboratories, they were in each case recounted by an analyst from the laboratory different from that in which the slides were made. All analysts standardized their microscopes, and used a special ocular micrometer as already described, so that each examined the central portion of the field only, and each examined 1/600,000 cc. of dried milk per field. A complete record was kept of the size of all groups seen.

The effect of the greater care taken in making the "counts," and in the increased skill gained thru the experience of the previous series is seen in Table XLI, where the average "counts" are summarized. Even a cursory examination will show that these results harmonize much more closely than before, and that variations in count from the same samples as great as 100 per cent are practically absent. This is marked improvement over the results from Series B as given in Table XIX.

Moreover, a study of the detailed records given in Tables XXIX to XL indicates that the less experienced men returned "counts" which bear evidence on their face of a greater accuracy than those returned by the same men from Series B. None of the men, for example, found more than an occasional bacterium or pair of bacteria in the high grade fresh milk used in Sample No. 1, whereas, in the previous series, the inexperienced men did not scrutinize the objects which they found in Sample No. 1 closely enough, and evidently recorded and counted objects as bacteria which were not bacteria.

On the other hand, in the samples of inoculated milk where the bacteria were numerous, the less experienced men still showed a tendency to report fewer bacteria than did the experienced men who examined the identical slides. This effect is particularly noticeable in the "counts" made by the analyst (H) who had had the least experience in microscopic counting. That this effect is chargeable to inexperience and not to carelessness is shown by the fact that the

TABLE XXIX.—SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made and counted by Analyst A.

Sample no.	Groups of 1	2	3	4	5	6	7	8	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	1	....	....	....	....	....	....	....	6,000	6,000	....	....
	....	....	....	....	....	....	....	....	000	000	3,000	3,000
2	60	53	1	2	....	....	1	....	702,000	1,104,000	....	....
	67	51	5	....	1	....	....	....	744,000	1,134,000	723,000	1,119,000
3	56	54	3	1	....	....	....	....	684,000	1,062,000	....	....
	46	66	1	1	....	....	....	....	684,000	1,110,000	684,000	1,086,000
4	54	63	4	2	....	....	....	1	744,000	1,248,000	....	....
	63	57	3	4	1	....	....	....	768,000	1,242,000	756,000	1,245,000
5	133	98	5	3	1	....	....	....	1,440,000	2,166,000	....	....
	128	110	9	2	....	1	....	....	1,500,000	2,334,000	1,470,000	2,250,000
6	119	104	5	3	....	....	2	....	1,398,000	2,208,000	....	....
	118	103	5	7	1	1	....	....	1,410,000	2,268,000	1,404,000	2,238,000
7	123	105	5	2	....	....	....	....	1,410,000	2,136,000	....	....
	135	107	2	4	....	....	1	....	1,494,000	2,268,000	1,452,000	2,202,000
8	262	197	21	9	1	1	....	....	2,946,000	4,596,000	....	....
	230	195	14	8	....	....	1	....	2,688,000	4,206,000	2,817,000	4,401,000
9	232	214	16	8	....	....	....	....	2,820,000	4,440,000	....	....
	195	202	10	8	4	1	....	....	2,520,000	4,122,000	2,670,000	4,281,000
10	225	197	18	13	1	1	....	....	2,730,000	4,416,000	....	....
	237	217	14	6	....	....	....	....	2,844,000	4,422,000	2,787,000	4,419,000
Totals 2 to 10	2,483	2,193	141	83	10	5	5	1				

Ratio 1:2.00:3.79 for the group "counts."   1:1.94:3.80 for the individual "counts."

TABLE XXX.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst A. Counted by Analyst I.

Sample no.	Groups of							No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	1	2	3	4	7	8	28				
1	......	......	......	....	....	....	....	Less than 6,000	Less than 6,000	....	....
	......	......	......	....	....	....	....	Less than 6,000	Less than 6,000	Less than 3,000	Less than 3,000
2	73	37	......	....	....	....	....	560,000	882,000	....	....
	64	37	......	....	....	....	....	606,000	828,000	633,000	855,000
3	74	49	1	....	....	....	....	744,000	1,050,000	....	....
	63	34	......	....	....	....	....	582,000	786,000	663,000	918,000
4	56	42	......	....	....	....	....	588,000	840,000	....	....
	66	53	1	....	....	....	....	720,000	1,050,000	654,000	945,000
5	119	78	1	....	....	....	....	1,188,000	1,668,000	....	....
	135	99	4	....	....	....	....	1,428,000	2,070,000	1,308,000	1,869,000
6	147	79	4	....	....	....	....	1,380,000	1,902,000	....	....
	119	89	3	....	....	....	....	1,266,000	1,854,000	1,323,000	1,878,000
7	114	83	1	....	....	....	....	1,188,000	1,698,000	....	....
	150	84	......	1	....	....	....	1,410,000	1,932,000	1,299,000	1,815,000
8	256	151	2	....	....	....	1	2,460,000	3,552,000	....	....
	260	194	6	1	....	....	....	2,766,000	4,020,000	2,613,000	3,786,000
9	311	204	4	1	....	....	....	3,120,000	4,410,000	....	....
	260	161	2	....	....	....	....	2,538,000	3,528,000	2,829,000	3,969,000
10	292	183	6	1	1	1	....	2,904,000	4,158,000	....	....
	293	210	5	1	1	....	....	3,060,000	4,428,000	2,982,000	4,293,000
Totals 2 to 10	2,852	1,867	40	5	2	1	1				

Ratio 1: 2.02: 4.32 for the group "counts." 1: 2.04: 4.43 for the individual "counts."

TABLE XXXI.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made and counted by Analyst B.

Sample no.	Groups of 1	2	3	4	5	6	8	10	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	1	....	....	1	....	....	....	....	12,000	30,000	....	....
	....	....	....	....	....	....	....	....	000	000	6,000	15,000
2	90	49	3	2	....	1	....	1	876,000	1,326,000	....	....
	80	30	....	....	....	....	....	....	660,000	840,000	768,000	1,063,000
3	119	45	2	1	....	....	....	....	1,002,000	1,314,000	....	....
	102	39	1	1	....	....	....	....	858,000	1,122,000	930,000	1,218,000
4	103	54	2	1	....	....	....	....	960,000	1,326,000	....	....
	93	44	3	1	1	....	....	....	852,000	1,194,000	906,000	1,260,000
5	174	95	2	3	....	....	....	....	1,644,000	2,292,000	....	....
	153	74	3	3	1	....	....	....	1,404,000	1,962,000	1,524,000	2,127,000
6	154	83	3	6	1	....	....	....	1,482,000	2,148,000	....	....
	163	93	6	7	....	....	....	....	1,614,000	2,370,000	1,548,000	2,259,000
7	175	93	8	5	1	....	....	....	1,692,000	2,460,000	....	....
	158	95	2	3	....	....	....	....	1,548,000	2,196,000	1,620,000	2,328,000
8	393	179	10	5	1	3	....	....	3,546,000	4,944,000	....	....
	375	173	13	3	1	....	1	....	3,396,000	4,710,000	3,471,000	4,827,000
9	379	157	4	7	1	....	....	....	3,288,000	4,428,000	....	....
	418	196	6	3	....	....	....	....	3,738,000	5,040,000	3,513,000	4,734,000
10	341	183	14	7	....	1	1	1	3,288,000	4,806 000	....	....
	360	186	11	8	1	1	....	....	3,402,000	4,848,000	3,345,000	4,827,000
Totals 2 to 10	3,830	1,868	93	66	8	6	2	2				

Ratio 1:1.80:3.96 for the group "counts."   1:1.89:4.03 for the individual "counts."

TABLE XXXII.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst B. Counted by Analyst H.

Sample no.	Groups of								No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	1	2	3	4	5	6	8	12				
1	1	....	....	....	....	....	....	....	6,000	6,000	....	....
	2	....	....	....	....	....	....	....	12,000	12,000	9,000	9,000
2	22	26	....	....	....	....	....	....	288,000	444,000	....	....
	40	21	....	....	....	....	....	....	366,000	492,000	327,000	468,000
3	26	15	1	....	....	....	....	....	252,000	354,000	....	....
	27	13	2	....	....	....	....	....	252,000	354,000	252,000	354,000
4	35	20	....	....	....	....	....	....	330,000	450,000	....	....
	50	20	....	....	....	....	....	....	420,000	540,000	375,000	495,000
5	46	34	3	1	....	....	....	....	504,000	762,000	....	....
	50	42	1	....	....	....	....	....	558,000	822,000	531,000	792,000
6	29	28	6	3	....	....	....	....	396,000	690,000	....	....
	56	21	....	2	....	....	....	....	474,000	636,000	435,000	663,000
7	55	32	3	1	....	....	....	....	546,000	756,000	....	....
	59	27	6	....	1	....	....	....	558,000	816,000	552,000	786,000
8	141	106	7	8	....	....	....	....	1,572,000	2,436,000	....	....
	153	113	10	2	3	1	1	....	1,698,000	2,676,000	1,635,000	2,556,000
9	162	116	7	5	1	1	1	1	1,764,000	2,796,000	....	....
	165	111	8	4	....	....	....	....	1,728,000	2,586,000	1,746,000	2,691,000
10	226	143	10	2	....	....	1	....	2,292,000	3,348,000	....	....
	206	157	16	12	1	....	....	....	2,352,000	3,726,000	2,322,000	3,537,000
Totals 2 to 10	1,548	1,045	80	40	6	2	3	1				

Ratio 1:1.59:5.98 for the group "counts." 1:1.70:6.67 for the individual "counts."

TABLE XXXIII.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made and counted by Analyst E.

Sample no.	Groups of 1	2	3	4	5	6	7	8	19	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	3	....	....	....	....	....	....	....	....	18,000	18,000	27,000	30,000
	5	1	....	....	....	....	....	....	....	36,000	42,000		
2	53	67	5	1	1	....	....	1	....	762,000	1,266,000	774,000	1,290,000
	62	59	6	2	1	....	....	....	....	786,000	1,314,000		
3	63	64	6	4	....	....	....	....	1	828,000	1,464,000	777,000	1,326,000
	60	52	4	4	....	1	....	....	....	726,000	1,188,000		
4	69	68	....	3	....	....	....	....	....	840,000	1,302,000	798,000	1,275,000
	58	60	3	4	1	....	....	....	....	756,000	1,248,000		
5	111	123	9	5	1	1	1	....	....	1,506,000	2,532,000	1,485,000	2,394,000
	131	112	6	4	....	....	1	....	....	1,464,000	2,256,000		
6	111	117	10	5	1	....	....	....	....	1,464,000	2,400,000	1,560,000	. ,496,000
	130	138	6	2	....	....	....	....	....	1,656,000	2,592,000		
7	106	139	7	3	1	2	....	1	....	1,554,000	2,652,000	1,512,000	2,514,000
	111	122	8	3	1	....	....	....	....	1,470,000	2,376,000		
8	272	205	11	8	4	....	1	....	....	3,006,000	4,644,000	3,102,000	4,803,000
	269	244	12	7	....	1	....	....	....	3,198,000	4,962,000		
9	31	227	10	13	3	....	....	....	....	3,504,000	5,292,000	3,327,000	5,268,000
	224	275	11	10	3	2	....	....	....	3,150,000	5,244,000		
10	187	278	14	5	2	3	1	....	....	2,940,000	5,040,000	3,015,000	5,187,000
	199	281	22	10	....	....	2	1	....	3,090,000	5,334,000		
Totals 2 to 10	2,547	2,621	150	93	19	10	6	3	1				

Ratio 1:1.94:4.02 for the group "counts." 1:1.90:3.92 for the individual "counts."

TABLE XXXIV.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst E. Counted by Analyst F.

Sample no.	Groups of 1	2	3	4	5	6	8	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	....	1	....	....	....	....	....	6,000	12,000	....	....
	....	....	....	....	....	....	....	000	000	3,000	6,000
2	61	47	1	2	....	....	....	666,000	996,000	....	....
	53	50	3	1	1	....	....	648,000	1,026,000	657,000	1,011,000
3	47	24	2	....	2	....	....	450,000	666,000	....	....
	49	48	1	1	....	....	....	594,000	912,000	522,000	789,000
4	66	29	2	....	1	....	....	588,000	810,000	....	....
	35	38	1	1	....	....	....	450,000	708,000	519,000	759,000
5	86	88	2	....	1	....	....	1,062,000	1,638,000	....	....
	102	59	5	....	....	....	....	996,000	1,410,000	1,029,000	1,524,000
6	107	95	2	1	....	....	....	1,230,000	1,842,000	....	....
	124	96	1	....	....	....	....	1,326,000	1,914,000	1,278,000	1,878,000
7	125	95	9	3	1	1	....	1,404,000	2,190,000	....	....
	101	107	1	5	....	....	....	1,284,000	2,028,000	1,344,000	2,109,000
8	233	144	5	3	....	....	....	2,310,000	3,288,000	....	....
	212	165	7	....	1	1	....	2,316,000	3,444,000	2,313,000	3,366,000
9	247	200	7	7	....	....	....	2,766,000	4,176,000	....	....
	269	219	12	1	....	....	....	3,006,000	4,482,000	2,886,000	4,329,000
10	241	222	3	6	1	1	1	2,850,000	4,422,000	....	....
	294	234	7	2	2	....	....	3,234,000	4,806,000	3,042,000	4,614,000
Totals 2 to 10	2,452	1,960	71	33	10	3	1				

Ratio 1:2.15:4.85 for the group "counts." 1:2.15:4.81 for the individual "counts."

TABLE XXXV.— SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made and counted by Analyst F.

Sample no.	Groups of 1	2	3	4	5	6	7	8	36	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	....	1	....	....	....	....	....	....	....	6,000	12,000	....	....
	....	....	....	....	....	....	....	....	....	000	000	3,000	6,000
2	77	63	5	....	....	....	....	....	....	870,000	1,308,000	....	....
	73	34	3	....	....	....	1	....	....	666,000	942,000	768,000	1,125,000
3	72	44	4	1	....	....	1	....	....	732,000	1,098,000	....	....
	65	36	2	....	....	....	....	....	....	618,000	858,000	675,000	978,000
4	99	63	3	2	1	....	....	....	....	1,008,000	1,482,000	....	....
	81	48	2	1	....	....	....	....	....	792,000	1,122,000	900,000	1,302,000
5	133	111	4	2	....	....	1	....	....	1,506,000	2,292,000	....	....
	140	120	4	4	1	....	1	....	....	1,620,000	2,520,000	1,563,000	2,406,000
6	126	92	1	....	....	1	....	....	....	1,320,000	1,914,000	....	....
	150	88	9	2	....	....	....	....	....	1,494,000	2,166,000	1,407,000	2,040,000
7	123	81	1	4	....	....	....	....	....	1,254,000	1,824,000	....	....
	120	81	9	2	....	....	2	....	1	1,290,000	2,202,000	1,272,000	2,013,000
8	323	171	11	6	2	1	....	....	....	3,084,000	4,428,000	....	....
	234	116	13	4	1	1	....	....	....	2,214,000	3,192,000	2,649,000	3,810,000
9	362	155	11	5	3	1	....	....	....	3,222,000	4,476,000	....	....
	293	175	2	4	....	....	....	1	....	2,850,000	4,038,000	3,036,000	4,257,000
10	231	89	10	2	....	....	....	....	....	1,992,000	2,682,000	1,992,000	2,682,000
Totals* 2 to 10	2,702	1,567	94	39	8	4	6	1	1				

* From 17 instead of the usual 18 preparations.

Ratio 1:1.81:3.28 for the group "counts." 1:1.90:3.16 for the individual "counts."

TABLE XXXVI.—SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst F. Counted by Analyst E.

Sample no.	Groups of 1	2	3	4	5	6	7	8	9	10	22	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	....	....	....	....	....	....	....	....	....	....	....	Less than 6,000	Less than 6,000	....	....
	....	....	....	....	....	....	....	....	....	....	....	Less than 6,000	Less than 6,000	Less than 3,000	Less than 3,000
2	64	60	4	2	....	....	....	....	....	....	....	780,000	1,224,000	....	....
	58	56	3	1	....	....	....	....	....	....	....	708,000	1,098,000	744,000	1,161,000
3	30	54	3	2	....	....	....	....	....	....	....	534,000	930,000	....	....
	68	75	2	1	....	....	1	....	....	....	....	882,000	1,410,000	708,000	1,170,000
4	50	57	4	1	....	1	....	1	....	....	....	684,000	1,164,000	....	....
	60	62	6	....	1	1	....	....	....	....	....	780,000	1,278,000	732,000	1,221,000
5	97	116	9	4	2	....	....	....	....	....	....	1,368,000	2,292,000	....	....
	135	147	12	3	2	....	....	....	....	....	1	1,800,000	3,054,000	1,584,000	2,673,000
6	118	102	11	5	....	....	....	....	1	....	....	1,422,000	2,304,000	....	....
	115	103	5	6	....	....	....	....	....	....	....	1,374,000	2,160,000	1,398,000	2,232,000
7	134	140	11	4	1	....	1	....	....	....	....	1,746,000	2,850,000	....	....
	124	129	4	5	....	2	1	....	....	....	....	1,590,000	2,598,000	1,668,000	2,724,000
8	222	211	12	8	1	2	....	1	....	....	....	2,742,000	4,422,000	....	....
	191	141	15	10	1	3	....	1	....	....	....	2,172,000	3,534,000	2,457,000	3,978,000
9	212	214	8	9	2	1	....	....	1	....	....	2,682,000	4,350,000	....	....
	207	229	16	11	5	....	1	....	....	....	....	2,814,000	4,734,000	2,748,000	4,542,000
10	220	210	14	9	....	1	1	....	1	....	....	2,736,000	4,440,000	....	....
	218	200	6	11	3	....	....	....	....	1	....	2,634,000	4,230,000	2,685,000	4,335,000
Totals 2 to 10	2,323	2,306	145	92	18	11	5	3	3	1	1				

Ratio 1:2.13:3.61 for the group "counts." 1:2.15:3.62 for the individual "counts."

TABLE XXXVII.—SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made and counted by Analyst H.

Sample no.	Groups of 1	2	3	4	5	6	7	9	10	12	No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals
1	2										12,000	12,000		
											000	000	6,000	6,000
2	67	23	1	3							564,000	768,000		
	63	25	1	1	1						546,000	750,000	555,000	759,000
3	37	17	2								336,000	462,000		
	52	26	1								474,000	642,000	405,000	552,000
4	29	15	1	1							276,000	396,000		
	40	38	5	2							510,000	834,000	393,000	615,000
5	134	76	4	4							1,308,000	1,884,000		
	119	49	3	3	2						1,056,000	1,488,000	1,182,000	1,686,000
6	64	51	5								720,000	1,086,000		
	86	51	7	2	1						882,000	1,332,000	801,000	1,209,000
7	30	36	1	3							420,000	702,000		
	71	58	3		1						798,000	1,158,000	609,000	930,000
8	158	94	8	4	3						1,602,000	2,466,000		
	164	98	11	3	1						1,662,000	2,460,000	1,632,000	2,463,000
9	144	150	10	3		1				1	1,854,000	3,006,000		
	125	109	5	7	1			1			1,488,000	2,406,000	1,671,000	2,706,000
10	135	94	15	2	3		1				1,500,000	2,388,000		
	198	168	21	7	3	1			1		2,394,000	3,960,000	1,947,000	3,174,000
Totals 2 to 10	1,716	1,178	104	45	16	2	1	1	1	1				

Ratio 1:1.92:3.88 for the group "counts." 1:1.99:4.33 for the individual "counts."

TABLE XXXVIII.—SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst H. Counted by Analyst B.

Sample no.	Groups of								No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	1	2	3	4	5	6	8	10				
1	....	....	....	....	....	....	....	....	Less than 6,000	Less than 6,000	....	....
	....	....	....	....	....	....	....	....	Less than 6,000	Less than 6,000	Less than 3,000	Less than 3,000
2	102	32	5	....	....	....	....	....	834,000	1,086,000	....	....
	115	36	4	1	....	....	....	....	936,000	1,218,000	885,000	1,152,000
3	112	44	4	2	....	....	....	....	972,000	1,320,000	....	....
	102	42	2	1	....	....	....	....	882,000	1,176,000	927,000	1,248,000
4	110	39	3	4	....	2	....	1	954,000	1,410,000	....	....
	103	43	1	....	....	....	....	....	882,000	1,152,000	918,000	1,281,000
5	299	89	10	1	1	....	....	....	2,400,000	3,096,000	....	....
	259	92	5	8	1	....	....	....	2,190,000	2,970,000	2,295,000	3,033,000
6	186	65	3	3	....	....	....	....	1,542,000	2,022,000	....	....
	189	56	5	1	....	1	....	....	1,512,000	1,956,000	1,527,000	1,989,000
7	204	55	3	2	....	....	....	....	1,584,000	1,986,000	....	....
	....	....	....	....	....	(Slide lost)		....	....	....	1,584,000	1,986,000
8	499	166	10	2	1	....	....	....	4,068,000	5,244,000	....	....
	437	138	12	5	....	....	1	1	3,564,000	4,722,000	3,816,000	4,983,000
9	408	156	9	6	....	....	....	....	3,474,000	4,626,000	....	....
	474	155	8	4	2	....	....	....	3,858,000	5,004,000	3,666,000	4,815,000
10	475	165	6	9	2	....	....	2	3,954,000	5,334,000	....	....
	455	172	7	5	1	....	....	1	3,846,000	5,130,000	3,900,000	5,232,000
Totals* 2 to 10	4,529	1,545	97	54	8	3	1	5				

* From 17 instead of the usual 18 preparations.

Ratio 1:1.08:4.17 for the group "counts." 1:1.00:4.08 for the individual "counts."

Table XXXIX.— Series C. Analyses of Samples of Fresh Milk Inoculated with the Colon Organism.

Microscopic preparations made and counted by Analyst I.

Sample no.	Groups of						No. of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
	1	2	3	4	5	6				
1	......	......	......	......	....	....	Less than 6,000	Less than 6,000	....	....
	......	......	......	......	....	....	Less than 6,000	Less than 6,000	Less than 3,000	Less than 3,000
2	62	44	......	......	....	....	636,000	900,000	....	....
	81	57	4	1	....	....	858,000	1,266,000	747,000	1,083,000
3	79	41	1	......	....	....	726,000	984,000	....	....
	74	55	3	......	....	....	792,000	1,158,000	759,000	1,071,000
4	68	42	3	2	....	....	690,000	1,014,000	....	....
	85	50	......	......	....	....	810,000	1,110,000	750,000	1,062,000
5	123	95	4	......	....	....	1,332,000	1,950,000	....	....
	172	100	2	2	....	....	1,656,000	2,316,000	1,494,000	2,133,000
6	130	91	3	......	1	1	1,356,000	1,992,000	....	....
	154	86	3	......	....	....	1,458,000	2,010,000	1,407,000	2,001,000
7	140	87	6	......	....	....	1,398,000	1,992,000	....	....
	155	97	4	2	....	....	1,548,000	2,214,000	1,473,000	2,103,000
8	370	220	10	3	....	....	3,618,000	5,112,000	....	....
	315	204	8	1	....	....	3,168,000	4,506,000	3,393,000	4,809,000
9	351	187	4	2	....	....	3,264,000	4,470,000	....	....
	309	193	6	......	2	....	3,060,000	4,338,000	3,162,000	4,404,000
10	370	169	6	1	....	....	3,276,000	4,380,000	....	....
	327	140	......	......	....	....	2,802,000	3,642,000	3,039,000	4,011,000
Totals 2 to 10	3,365	1,958	67	14	3	1				

Ratio 1:1.94:4.25 for the group "counts."   1:1.94:4.11 for the individual "counts."

TABLE XL.—SERIES C. ANALYSES OF SAMPLES OF FRESH MILK INOCULATED WITH THE COLON ORGANISM.

Microscopic preparations made by Analyst I. Counted by Analyst A.

Sample no.	Groups of 1	2	3	4	5	6	7	8	No of groups per cc.	No. of individuals per cc.	Ave. no. groups.	Ave. no. individuals.
1	1	....	....	....	....	....	....	....	6,000	6,000	....	....
	1	1	....	....	....	....	....	....	12,000	18,000	9,000	12,000
2	82	48	2	2	....	....	....	....	804,000	1,152,000	....	....
	92	42	5	....	....	....	....	....	834,000	1,146,000	819,000	1,149,000
3	80	50	2	2	....	....	....	....	804,000	1,164,000	....	....
	81	49	4	4	1	....	1	....	840,000	1,314,000	822,000	1,239,000
4	70	41	3	2	....	1	....	....	702,000	1,050,000	....	....
	90	48	2	....	....	....	....	....	840,000	1,152,000	771,000	1,101,000
5	144	90	9	2	1	1	....	....	1,482,000	2,220,000	....	....
	160	137	13	2	2	....	....	....	1,884,000	2,946,000	1,683,000	2,583,000
6	175	108	10	6	1	....	....	....	1,800,000	2,700,000	....	....
	162	100	10	3	1	....	....	....	1,656,000	2,454,000	1,728,000	2,577,000
7	151	99	8	2	....	....	....	....	1,560,000	2,286,000	....	....
	152	67	3	1	....	....	....	....	1,338,000	1,794,000	1,449,000	2,040,000
8	351	224	10	9	3	1	....	....	3,588,000	5,316,000	....	....
	338	212	12	6	....	2	....	....	3,420,000	5,004,000	3,504,000	5,160,000
9	312	192	8	1	2	1	....	....	3,096,000	4,440,000	....	....
	352	246	12	6	4	....	....	1	3,726,000	5,592,000	3,411,000	5,016,000
10	386	226	14	16	....	....	....	....	3,852,000	5,664,000	....	....
	333	197	9	7	2	1	....	....	3,294,000	4,788,000	3,573,000	5,226,000
Totals 2 to 10	3,511	2,176	136	71	17	7	1	1				

Ratio 1:2.01:4.35 for the group "counts."   1:2.06:4.41 for the individual "counts."

plate "counts" returned by the men who made the irregular microscopic "counts" are as regular, and presumably as accurate, as any that were made. The difficulties which the inexperienced men met were similar, in a general way, to those with which every analyst meets who undertakes to make agar plate "counts" for the first time; as, for instance, failure to record essential data, failure to appreciate which steps in the technique must be carried out with precision, and which may be modified without affecting results, and the like.

An examination of the ratios, as given at the bottom of Tables XXIX to XL, shows that all of the analysts (with the single exception of Analyst H, see Table XXXII) obtained ratios which agree well with the expected ratio of 1:2:4. A marked improvement was shown in these over the similar ratios from Series B. The final average ratios obtained were 1:1.95:4.11 for the group "counts" and 1:1.97:4.12 for the individual "counts." These are almost identical with the expected ratios, and are even more nearly perfect than the similar ratios from the plate "counts."

In order that the differences in "counts" may be studied more readily, the maximum and minimum "counts" returned by all of the analysts are given in Table XLIII, while those returned by the two analysts who had the greatest amount of experience in microscopic counting are given in Table XLIV. From these it becomes evident that the greater number of the maximum "counts" from the inoculated samples (10 out of a possible 16) were returned by the two experienced analysts. On the other hand, all of the minimum "counts" were returned by the single analyst (H) who was least experienced in this technique.

In Series C, as in Series B, the maximum "counts" reported by the experienced men for any sample numbered 2, 3, or 4, never exceeded the minimum "counts" which they reported for any sample numbered 5, 6, or 7. Likewise, the "counts" reported by these men for any sample numbered 5, 6, or 7 never exceeded the minimum "count" reported for any sample numbered 8, 9, or 10. The less experienced men were not as fortunate in this respect, and there is a constant overlapping of the "counts" in such a way as to show that some of them must have been quite inaccurate.

The greater regularity of these microscopic "counts" as contrasted with those of Series B is brought out by a comparison of the coefficients of variability as recorded for Series C in Table XLI and for Series B in Table XX. All of the coefficients of variability are less for Series C than those for Series B, and in several instances indicate less variation of the microscopic "counts" from the mean than were observed in the plate "counts" of Series B. The average coefficient of variability for the group "counts" of Series C is 11.7, while that for the individual "counts" is 13.4. These averages are decidedly better than the similar averages of 24.1, and 28.3 for

Series B. This improvement is undoubtedly to be charged to the greater skill of the analysts gained thru their experience in the work of the previous series, and to the improved technique.

C. COMPARISON BETWEEN THE PLATE AND MICROSCOPIC COUNTS

When the "counts" of Series C as made by the two different methods are compared, the unique character of the results at once becomes evident. As already indicated, they meet the checks and counterchecks made upon their accuracy thus far discussed even more perfectly than those of Series B.

They likewise very perfectly meet the test of comparison with each other, which is very severe in this case as the average number of individuals per group (1.45) was even less than before. However, in spite of this, every one of the final average plate "counts" as recorded in Table XLI are intermediate in size between the group and individual "counts." Even when the averages as returned by the individual men are examined, it will be seen that only three of the group "counts" out of a possible 54 are larger than the corresponding plate "counts," while only ten of the individual "counts" out of a possible 54 are smaller than the corresponding plate "counts" from the same samples. Moreover, eight of these were made by the one analyst (H) who, as already explained, evidently returned microscopic counts which were lower than they should have been.

Thus it becomes practically a certainty that there cannot be a large error in the final average figures, and that they actually show, in the one case, the number of groups originally present in the milk; in the second case, the number of centers of growth which existed after the partial disintegration of the clumps in the dilution waters; and, in the third case, the actual number of individual bacteria present.

Computation, based on the final average figures given in Table XLI, shows that, as in Series B, the clumps were only partially broken apart in making the agar plates. Thus, whereas the average group of organisms in Samples Nos. 2, 3, and 4 contained 1.47 individuals in the milk itself, the groups in the final dilutions used in making the plates contained 1.24 individuals. Likewise, whereas the original groups in the milk in Samples Nos. 5, 6, and 7 contained 1.48 individuals, the groups in the final dilution water contained 1.25 individuals. In the third group of samples (8, 9, and 10), the average group in the milk itself contained 1.49 individuals, whereas the average group in the final dilution waters was reduced to 1.16 individuals. Thus, even under these very favorable conditions, the agar plate "counts" only approximate the number of bacteria present.

TABLE XLI.— SERIES C. SUMMARY OF PLATE AND MICROSCOPIC "COUNTS."

Sample no.	Analyst †	Plate "count." Combined average.‡	Analyst †	Group "count." Average for each analyst.	Group "count." Combined average.	Individual "count." Average for each analyst.	Individual "count." Combined average.
*1		623			5,500		7,250
2-4	BB	885,000	BB	§868,000	593,000	§1,187,000	813,000
	BC		BH	318,000		439,000	
	CC	784,000	AA	721,000	685,000	1,150,000	1,028,000
	CE		AI	650,000		906,000	
	EE	755,000	EE	783,000	674,000	1,297,000	1,075,000
	EB		EF	566,000		853,000	
	FF	842,000	FF	781,000	754,000	1,135,000	1,160,000
	FH		FE	728,000		1,184,000	
	HH	830,000	HH	451,000	680,000	642,000	935,000
	HI		HB	910,000		1,227,000	
	II	827,000	II	752,000	778,000	1,072,000	1,117,000
	IF		IA	804,000		1,163,000	
Final ave.—		821,000			694,000		1,021,000
5-7	BB	1,605,000	BB	§1,564,000	1,035,000	§2,238,000	1,493,000
	BC		BH	506,000		747,000	
	CC	1,470,000	AA	1,442,000	1,376,000	2,230,000	2,042,000
	CE		AI	1,310,000		1,854,000	
	EE	1,620,000	EE	1,519,000	1,368,000	2,468,000	2,152,000
	EB		EF	1,217,000		1,837,000	
	FF	1,715,000	FF	1,414,000	1,482,000	2,153,000	2,348,000
	FH		FE	1,550,000		2,543,000	
	HH	1,610,000	HH	864,000	1,333,000	1,275,000	1,806,000
	HI		HB	1,802,000		2,336,000	
	II	1,670,000	II	1,458,000	1,539,000	2,079,000	2,240,000
	IF		IA	1,620,000		2,400,000	
Final ave.—		1,615,000			1,356,000		2,014,000
8-10	BB	3,600,000	BB	§3,443,000	2,672,000	§4,796,000	3,862,000
	BC		BH	1,901,000		2,928,000	
	CC	3,710,000	AA	2,758,000	2,783,000	4,367,000	4,191,000
	CE		AI	2,808,000		4,016,000	
	EE	3,680,000	EE	3,148,000	2,947,000	5,086,000	4,594,000
	EB		EF	2,747,000		4,102,000	
	FF	3,620,000	FF	2,559,000	2,595,000	3,583,000	3,934,000
	FH		FE	2,630,000		4,285,000	
	HH	3,340,000	HH	1,750,000	2,772,000	2,781,000	3,895,000
	HI		HB	3,794,000		5,010,000	
	II	3,890,000	II	3,198,000	3,347,000	4,408,000	4,771,000
	IF		IA	3,496,000		5,134,000	
Final ave.—		3,640,000			2,853,000		4,208,000

* Detailed results for Sample 1 are given in Table LXV, page 226.
† The first analyst named made the plates or slides, the second counted them.
‡ The individual averages will be found in Tables XXIII to XXVIII.
§ As all analysts examined 1 cu. mm. of milk in making these "counts," the exact number of groups, or of bacteria seen is obtained by dividing this figure by 1000.

TABLE XLII.—SERIES C. SUMMARY OF TABLE XLI.

Sample no.	Plate "count."			Group "count."			Individual "count."		
	Final averages.	Standard deviation.	Coefficient variation.	Final averages.	Standard deviation.	Coefficient variation.	Final averages.	Standard deviation.	Coefficient variation.
2-4	821,000	58,200	7.1	694,000	69,000	10.0	1,021,000	127,000	12.5
5-7	1,615,000	115,000	7.1	1,356,000	204,000	15.0	2,014,000	347,000	17.3
8-10	3,640,000	385,000	10.6	2,853,000	286,000	10.1	4,208,000	441,000	10.5
Ave..	....		8.3	....		11.7	....		13.4
	Ratio 1 :1.97 :4.43 1.00 :2.25			Ratio 1 :1.95 :4.11 1.00 :2.10			Ratio 1 :1.97 :4.12 1.00 :2.09		

Average number of bacteria per group — 1.48 individuals.

TABLE XLIII.—SERIES C. MAXIMUM AND MINIMUM PLATE AND MICROSCOPIC "COUNTS."

Sample no.	Plate "counts."		Group "counts."		Individual "counts."		Total no. "counts."
	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	
1........	450	1,150	Less than 3,000	27,000	Less than 3,000	30,000	12
	493	1,010	Less than 3,000	9,000	Less than 3,000	15,000	....
2-4......	703,000	937,000	252,000	930,000	354,000	1,326,000	36
	713,000	900,000	327,000	927,000	468,000	1,302,000	
5-7......	1,380,000	1,870,000	435,000	2,295,000	663,000	3,033,000	36
	1,420,000	1,840,000	531,000	1,728,000	786,000	2,724,000	....
8-10.....	2,950,000	4,600,000	1,632,000	3,900,000	2,463,000	5,268,000	36
	3,130,000	4,520,000	1,635,000	3,816,000	2,556,000	5,232,000	....

TABLE XLIV.— SERIES C. MAXIMUM AND MINIMUM MICROSCOPIC "COUNTS" OBTAINED BY THE ANALYSTS EXPERIENCED IN THIS TECHNIQUE.

Sample no.	Group "counts."		Individual "counts."		Total no. "counts."
	Minimum.	Maximum.	Minimum.	Maximum.	
1	Less than 3,000	9,000	Less than 3,000	15,000	4
	3,000	6,000	3,000	12,000	
2-4	684,000	930,000	1,086,000	1,281,000	12
	723,000	927,000	1,101,000	1,260,000	
5-7	1,404,000	2,295,000	1,986,000	3,033,000	12
	1,449,000	1,728,000	1,989,000	2,583,000	
8-10	2,670,000	3,900,000	4,281,000	5,232,000	12
	2,787,000	3,816,000	4,401,000	5,226,000	

SERIES A.—MISCELLANEOUS SAMPLES OF MILK

As explained previously (page 151), this series of analyses was the first one made, but it is discussed last as the results secured are in part explained by the results secured in Series B and C. Twenty samples were used for the analyses in Series A which were prepared in four lots of five each. Samples Nos. 1 to 5, and Nos. 11 to 15 were prepared and distributed from the Geneva laboratory, while Samples Nos. 6 to 10, and 16 to 20 were prepared and distributed from Ithaca. For convenience in comparison, the "count" from the similar samples (No. 1 in Series B, and No. 1 in Series C) have been retabulated and included in this series (see Tables LXVI and LXV).

Samples Nos. 1 to 5 were prepared from high grade fresh herd milk which had been refrigerated at 50° F. from 15 to 51 hours. Samples Nos. 6 to 10 were from Ithaca market milk which had been kept on ice for 24 hours previous to the preparation of the samples. Samples Nos. 11 to 15 were either specially prepared by inoculating a high grade fresh milk with a definite organism or were selected or so handled as to have a more or less definite and controlled flora. Samples Nos. 16 to 20 were similar to Samples Nos. 6 to 10, and were handled in a similar way. The samples from Series B and C were from the milk of one cow, known to show low counts, which was drawn into a small top sterilized pail. All samples were of unpasteurized milk.

As the samples used were miscellaneous in character, the results obtained have been tabulated separately for each sample. Thru a misunderstanding in regard to the labeling, only four or five of the seven analysts who participated in the work analyzed any one of the samples in the first group. But, because one or two men analyzed duplicate samples eight analyses are usually given. As Sample No. 3 was a duplicate of Sample No. 5, the results of both are combined in Table XLVII.

TABLE XLV.— SERIES A, SAMPLE NO. 1. GENEVA STATION HERD MILK WHICH HAD BEEN REFRIGERATED AT 50° F. FOR 15 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
B*-B*	9,300	9,000	123,000	The only clumps of bacteria reported from the microscopic slides which included 10 or more individuals were three clumps of 10, 12, and 36 individuals respectively reported by Analyst B; and one clump of 15 individuals reported by Analyst D. Analyst G also must have seen groups which were as large as these. The average group contained 5.5 individuals.
B-D	17,000	33,000	114,000	
C-C†	2,300	6,000	6,000	
C-B	2,400	12,000	87,000	
D-D	10,600	9,000	15,000	
D-C	9,600	12,000	21,000	
G-G	11,800	35,000	625,000	
G-E	9,700	....	....	
G-G	13,200	35,000	60,000	
G-E	10,600	....	....	
G-G	14,500	25,000	42,000	
G-E	13,600	....	....	
G-G	11,500	5,000	7,000	
G-E	10,000	....	....	
G-G	13,200	25,000	35,000	
G-E	10,600	....	....	
Averages	10,600	18,700	103,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the agar plates and slides.

† In this instance the agar plates were made and counted by Analyst C, while the microscopic slides were made and counted by Analyst A.

Table XLVI.— Series A, Sample no. 2. Geneva Station Herd Milk which had been Refrigerated at 50° F. for 27 Hours.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
B*-B*.....	7,000	27,000	84,000	The only clumps of bacteria reported from the microscopic slides which included 10 or more individuals were two clumps of 40 and 100 individuals, respectively, reported by Analyst D; and two clumps reported by Analyst B, which together included 60 individuals. The average group contained 4.7 individuals.
B-D.......	7,000	57,000	288,000	
C-C†......	8,000	21,000	39,000	
C-B........	9,000	6,000	123,000	
D-D.......	8,000	6,000	306,000	
D-C.......	6,000	3,000	6,000	
I-I........	13,000	25,000	47,000	
I-F........	16,000	....	....	
I-I........	13,000	3,000	3,000	
I-F........	13,000	....	....	
I-I........	12,000	8,000	11,000	
I-F........	10,000	....	....	
I-I........	11,000	11,000	22,000	
I-F........	9,000	....	....	
I-I........	13,000	49,000	85,000	
I-F........	11,000	....	....	
Averages...	10,400	19,600	92,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the agar plates and slides.

† In this instance the agar plates were made and counted by Analyst C, while the microscopic slides were made and counted by Analyst A.

TABLE XLVII.— SERIES A, SAMPLES NOS. 3 AND 5. GENEVA STATION HERD MILK WHICH HAD BEEN REFRIGERATED AT 50° F. FOR 39 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
B*-B*...	5,100	3,000	9,000	The only clumps of bacteria reported from the microscopic slides which included 10 or more individuals were two clumps of 10 and 12 individuals reported by Analyst D.
B-D.....	4,700	21,000	114,000	
B-B.....	5,000	Less than 3,000	Less than 3,000	
B-D.....	7,000	3,000	6,000	
C-C†....	6,000	6,000	6,000	
C-B.....	7,600	Less than 3,000	Less than 3,000	
C-C†....	6,900	3,000	3,000	The average group contained 3.0 individuals.
C-B.....	7,400	Less than 3,000	Less than 3,000	
D-D.....	5,800	6,000	9,000	Samples 3 and 5, as furnished to the analysts, were duplicates. As the reported counts were almost identical in all cases they are tabulated together.
D-C.....	4,300	Less than 3,000	Less than 3,000	
D-D.....	4,400	3,000	6,000	
D-C.....	4,100	6,000	18,000	
E-E.....	6,500	4,900	15,000	
E-G.....	5,500	....	....	
E-E.....	6,900	9,800	20,000	
E-G.....	5,600	....	....	
E-E.....	7,600	9,800	20,000	
E-G.....	6,900	....	....	
E-E.....	6,400	Less than 4,900	Less than 4,900	
E-G.....	5,300	....	....	
E-E.....	6,600	9,800	29,000	
E-G.....	6,400	....	....	
Averages.	6,000	5,000	15,000	

* The first analyst named made the agar plates and the microscopic slides. The second analyst named counted the agar plates and slides.

† In these instances, the agar plates were made and counted by Analyst C, while the microscopic slides were made and counted by Analyst A.

TABLE XLVII.— SERIES A, SAMPLE NO. 4. GENEVA STATION HERD MILK WHICH HAD BEEN REFRIGERATED AT 50° F. FOR 51 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
B*-B*.....	30,000	24,000	63,000	The only clumps of bacteria reported from the microscopic slides which included 10 or more individuals were nine clumps of 10, 10, 10, 10, 14, 18, 21, 32, and 35 individuals, respectively, reported by Analyst B; one clump of 12 individuals reported by Analyst A; and several groups of this size seen and counted by Analyst F.
B-B.......	30,000	105,000	528,000	
F-F........	2,300‡	38,000	97,000	
F-I........	3,600‡	....	....	
F-F........	3,600‡	120,000	239,000	
F-I........	3,150‡	....	....	
F-F........	3,100‡	36,000	77,000	
F-I........	3,700‡	....	....	
F-F........	3,200‡	8,500	29,000	The average group contained 3.5 individuals.
F-I........	3,300‡	....	....	
F-F........	3,300‡	1,800	3,600	
F-I........	4,100‡	....	....	
C†-C†.....	66,000	24,000	117,000	
C-D.......	87,000	24,000	111,000	
D-D.......	31,000	21,000	45,000	
D-B.......	28,000	51,000	285,000	
Averages...	45,000	41,000	145,000	

* The first analyst named made the agar plates and the microscopic slides. The second analyst named counted the agar plates and the slides.

† In this instance the agar plates were made and counted by Analyst C, while the microscopic slides were made and counted by Analyst A.

‡ These low "counts" were made from a whey-agar. As this did not prove a favorable medium for growing the bacteria present, the "counts" while consistent with each other are far less than the "counts" made from ordinary agar and are, therefore, not included in the average.

TABLE XLIX.— SERIES A, SAMPLE NO. 6. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*......	?	1,090,000‡	5,570,000‡	The clumps of bacteria reported from the microscopic slides which included more than 10 individuals were one clump of 115 individuals reported by Analyst A, three clumps containing 16, 68, and 10 individuals, respectively, reported by Analyst B, three clumps containing 11, 25, and 50 individuals, respectively, reported by Analyst D, and three clumps containing 12, 20, and 16 individuals, respectively, reported by Analyst G.
F-I........	?	....	....	
B-B.......	24,000	18,000	105,000	
B-C.......	33,000	24,000	384,000	
C-C†......	98,000	36,000	81,000	
C-B.......	96,000	12,000	48,000	
D-D.......	?	15,000	123,000	
D-B.......	?	9,000	21,000	
G-G.......	104,000	107,000	440,000	
G-E.......	120,000	....	....	Neither Analysts F nor I recorded the size of the clumps seen, but both evidently saw several clumps which included more than 10 individuals.
E-E.......	115,000	51,000	122,000	
E-G.......	105,000	....	....	
I-I.........	44,000	145,000	343,000	
I-F........	39,000	....	....	The average group contained 4.0 individuals.
Averages...	78,000	46,000	185,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the agar plates and slides.

† In this instance the agar plates were made and counted by Analyst C, while the microscopic slides were made and counted by Analyst A.

‡ Omitted from the average as the count was greatly influenced by a single very large clump of organisms.

TABLE L.—SERIES A, SAMPLE NO. 7. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*......	78,000	71,000	183,000	The clumps of bacteria reported from the microscopic slides which included 10 or more individuals were two clumps containing 22 and 78 individuals, respectively, reported by Analyst A, four clumps containing 12, 26 20, and 10 individuals, respectively, reported by Analyst B, two clumps containing 20 and 20 individuals, respectively, reported by Analyst G, and two clumps containing 12 and 12 individuals, respectively, reported by Analyst E.
F-I........	65,000	....	....	
B-B.......	40,000	21,000	111,000	
B-C.......	27,000	24,000	321,000	
C-C†......	52,000	57,000	162,000	
C-B.......	67,000	33,000	150,000	
D-D.......	?	33,000	96,000	
D-B.......	?	9,000	216,000	
G-G.......	82,000	41,000	295,000	
G-E.......	75,000	....	....	
E-E.......	78,000	86,000	316,000	Analysts F and I evidently saw clumps containing more than 10 individuals but did not record them separately.
E-G.......	62,000	....	....	
I-I.........	117,000	93,000	167,000	The average group contained 4.3 individuals.
I-F........	123,000	....	....	
Averages....	72,000	47,000	202,000	

* The first analyst named made the agar plates and the microscopic slides. The second analyst named counted the agar plates and slides.

† In this instance the agar plates were made and counted by Analyst C, while the microscopic slides were made and counted by Analyst A.

TABLE LI.—SERIES A, SAMPLE No. 8. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*......	19,000	4,500	4,500	The only clumps of bacteria reported from the microscopic slides which included 10 or more individuals were two clumps which together included 40 bacteria reported by Analyst G, one clump of 16 individuals reported by Analyst B, and four clumps (exact size not given) reported by Analyst E.
F-I........	22,000	....	....	
B-B.......	25,000	6,000	39,000	
B-C.......	23,000	12,000	27,000	
C-C†......	34,000	27,000	42,000	
C-B.......	37,000	9,000	18,000	
D-D.......	?	12,000	21,000	
D-B.......	?	42,000	321,000	
G-G.......	41,000	190,000	625,000	The average group contained 3.7 individuals.
G-E.......	44,000	....	....	
E-E.......	19,000	177,000	722,000	
E-G.......	16,000	....	....	
I-I.........	44,000	36,000	69,000	
I-F........	41,000	....	....	
Averages....	30,000	51,000	189,000	

* The first analyst named made the agar plates and the microscopic slides. The second analyst named counted the agar plates and slides.

† In this instance the agar plates were made and counted by Analyst C, while the microscopic slides were made and counted by Analyst A.

TABLE LII.— SERIES A, SAMPLE NO. 9. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*......	34,000	18,000	61,000	The only clumps of bacteria reported from the microscopic slides which included 10 or more individuals were six clumps reported by Analyst A, which included 16, 10, 30, 17, 14, and 12 individuals, respectively, eight clumps reported by Analyst B which included 11, 11, 12, 12, 14, 34, 10, and 18 individuals, respectively, three clumps reported by Analyst D which included 11, 33, and 16 individuals, three clumps reported by Analyst G which included 12, 14, and 16 individuals, respectively, and one clump of 10 individuals reported by Analyst E. Analysts F, I, and G saw other clumps including as many as 10 individuals but did not report their exact size. The average group contained 4.8 individuals.
F-I........	27,000	....	....	
B-B........	111,000	51,000	303,000	
B-C........	90,000	60,000	441,000	
C-C†......	150,000	84,000	294,000	
C-B........	118,000	27,000	138,000	
D-D.......	?	108,000	534,000	
D-B.......	?	39,000	339,000	
G-G........	135,000	180,000	950,000	
G-E........	120,000	....	....	
E-E........	105,000	144,000	521,000	
E-G........	91,000	....	....	
I-I.........	93,000	93,000	249,000	
I-F........	101,000	....	....	
Averages...	98,000	80,000	383,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the agar plates and slides.

† In this instance the agar plates were made and counted by Analyst C, while the microscopic slides were made and counted by Analyst A.

TABLE LIII.— SERIES A, SAMPLE NO. 10. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*......	248,000	30,000	129,000	A very large number of clumps including 10 or more individuals was reported, especially by Analysts A, B, and D. Thus Analyst A reported 18 clumps which included 24, 22, 10, 14, 70, 15, 15, 21, 15, 13, 50, 18, 26, 100, 33, 12, 14, and 15 individuals, respectively. Analyst B reported 20 clumps which included 48, 150, 18, 18, 10, 14, 20, 18, 12, 25, 16, 50, 30, 24, 12 14, 32, 10, 20, and 12 individuals, respectively. Four other clumps were seen which were of similar size but the exact number of individuals was not recorded. Analyst D found 11 clumps which included 32, 19, 11, 10, 11, 32, 400, 25, 14, 24, and 80 individuals, respectively. Analyst G found two clumps which included 14 and 18 individuals, respectively, also two others whose exact size was not recorded. Analyst E saw one clump of 13 individuals, while Analysts F and I did not record the size of the clumps seen.
F-I........	238,000	....	....	
B-B........	207,000	87,000	1,360,000	
B-C‡......	137,000	90,000	1,070,000	
C†-C‡......	215,000	174,000	1,020,000	
C†-B.......	294,000	76,000	570,000	
D-D.......	?	39,000	339,000	
D-B.......	?	87,000	807,000	
G-G........	309,000	81,000	418,000	
G-E........	328,000	....	....	
E-E........	336,000	184,000	476,000	
E-G........	256,000	....	....	
I-I.........	427,000	93,000	1,020,000	
I-F........	424,000	....	....	
Averages...	285,000	94,000	721,000	The average group contained 7.7 individuals.

* The first analyst named made the agar plates and the microscopic slides. The second analyst named counted the agar plates and the slides.

† In this instance the agar plates were made by Analyst C, while the microscopic slides were made by Analyst A.

‡ In this instance the agar plates were counted by Analyst C, while the microscopic slides were counted by Analyst A.

TABLE LIV.— SERIES A, SAMPLE No. 11. FRESH MILK INOCULATED WITH A CULTURE OF LONG-ROD, LACTIC ACID BACTERIA FROM CHEESE FACTORY WHEY.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*	68,000,000	75,000,000	77,000,000	Nearly all of the bacteria were found as single individuals in the microscopic slides. A few clumps of two or three individuals were noted.
F-I	47,000,000	102,000,000	112,000,000	
B-B	21,000,000	90,000,000	111,000,000	
B-D	10,000,000	81,000,000	94,000,000	
C†-C**	48,000‡	84,000,000	92,000,000	The average group contained 1.06 individuals.
C†-B	53,000,000‡	90,000,000	95,000,000	
D-D	28,000,000	89,000,000	93,000,000	The agar plates were covered with a few large, and innumerable tiny colonies some of which could be seen only under the compound microscope. Evidently the estimated numbers of the colonies on the plates did not include all of the microscopic colonies. Because of irregularities in the estimated numbers of colonies, the agar plate counts are very irregular.
D-C**	?	83,000,000	92,000,000	
G-G	74,000,000	103,000,000	108,000,000	
G-E	93,000,000	75,000,000	75,000,000	
E-E	23,000,000	126,000,000	126,000,000	
E-G	34,000,000	113,000,000	116,000,000	
I-I	81,000,000	85,000,000	90,000,000	
I-F	86,000,000	108,000,000	113,000,000	
Averages	52,000,000	93,000,000	99,000,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the agar plates and the slides.

** In this instance the agar plates were counted by Analyst C, while the microscopic slides were counted by Analyst A.

† In this instance the agar plates were made by Analyst C, while the slides were made by Analyst A.

‡ The reason for this great discrepancy in duplicate "counts" is merely that Analyst C made no attempt to estimate the number of tiny colonies on the plates. His "count" was not included in the final average.

TABLE LV.— SERIES A, SAMPLE No. 12. FRESH MILK INOCULATED WITH A SKIM MILK CULTURE OF THE COLON BACILLUS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*....	77,000,000	51,000,000	78,000,000	The great majority of these bacteria occurred as single isolated individuals. Some pairs and even a few larger clumps were seen; but no one reported seeing a clump containing as many as 10 individuals. The average group contained 1.4 individuals.
F-I......	57,000,000	65,000,000	99,000,000	
B-B......	40,000,000	44,000,000	54,000,000	
B-D......	39,000,000	38,000,000	45,000,000	
C†-C‡ ...	50,000,000	42,000,000	48,000,000	
C†-B	45,000,000	40,000,000	45,000,000	
D-D......	49,000,000	55,000,000	76,000,000	
D-C‡	45,000,000	37,000,000	48,000,000	
G-G......	50,000,000	88,000,000	120,000,000	
G-E	58,000,000	51,000,000	67,000,000	
E-E	38,000,000	53,000,000	100,000,000	
E-G	43,000,000	50,000,000	54,000,000	
I-I.	39,000,000	33,000,000	55,000,000	
I-F......	36,000,000	42,000,000	56,000,000	
Averages..	48,000,000	49,000,000	67,000,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the agar plates and the slide.

† In this instance the agar plates were made by Analyst C, while the slides were made by Analyst A.

‡ In this instance the agar plates were counted by Analyst C, while the microscopic slides were counted by Analyst A.

TABLE LVI.— SERIES A, SAMPLE No. 13. GENEVA STATION HERD MILK WHICH WAS KEPT IN AN INCUBATOR AT 37° C. FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*....	116,000,000	69,000,000	206,000,000	There were a number of clumps which contained 10 or more bacteria with some enormous clumps of micrococci which were readily found with low magnification. Apparently however only a few of the large clumps were seen in the microscopic fields which were examined when the counts were made. One examined by Analyst A was estimated to contain at least 6,000 bacteria. However, because of the very large number of small clumps and isolated bacteria, the average group contained only 4.4 individuals.
F-I......	94,000,000	64,000,000	176,000,000	
B-B......	130,000,000	27,000,000	136,000,000	
B-D......	140,000,000	20,000,000	112,000,000	
C†-C‡....	123,000,000	27,000,000	297,000,000	
C†-B.....	122,000,000	25,000,000	109,000,000	
D-D......	112,000,000	15,000,000	114,000,000	
D-C‡.....	115,000,000	29,000,000	110,000 000	
G-G......	224,000,000	47,000,000	123,000,000	
G-E......	267,000,000	46,000,000	193,000,000	
E-E......	95,000,000	50,000,000	180,000,000	
E-G......	83,000,000	37,000,000	182,000,000	
I-I......	118,000,000	50,000,000	152,000,000	
I-F......	152,000,000	60,000,000	187,000,000	
Averages..	135,000,000	37,000,000	163,000,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the agar plates and slides.

† In this instance the agar plates were made by Analyst C, while the slides were made by Analyst A.

‡ In this instance the agar plates were counted by Analyst C, while the slides were counted by Analyst A.

TABLE LVII.— SERIES A, SAMPLE No. 14. MARKET MILK CONTAINING MASSES OF LONG CHAIN STREPTOCOCCI KNOWN TO HAVE COME FROM AN INFECTED UDDER.

Analysis.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*....	9,200,000	8,900,000	188,000,000	Almost all of the bacteria present were in the chains characteristic of streptococci, and rarely did these chains contain fewer than 10 individual bacteria. The average group contained 25.4 individuals. The explanation of the high plate "counts" obtained by Analyst G is undoubtedly that the organisms grew better on the agar which he used (containing both lactose and dextrose, and both Witte's and Difco peptone) than on the simpler agars used by the others.
F-I......	9,000,000	3,000,000	89,000,000	
B-B.....	4,900,000	3,600,000	117,000,000	
B-D.....	6,000,000	3,500,000	146,000,000	
C†-C‡....	9,000,000	3,700,000	219,000,000	
C†-B.....	4,700,000	4,000,000	119,000,000	
D-D....	6,700,000	4,400,000	126,000,000	
D-C‡....	6,400,000	3,100,000	114,000,000	
G-G.....	25,000,000	5,600,000	61,000,000	
G-G.....	25,000,000	9,700,000	197,000,000	
E.-E....	6,300,000	13,000,000	303,000,000	
E-G.....	6,400,000	5,700,000	102,000,000	
I-I......	10,000,000	3,900,000	112,000,000	
I-F......	9,500,000	10,800,000	209,000,000	
Averages..	9,900,000	5,900,000	150,000,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the plates and slides.

† In this instance the agar plates were made by Analyst C, while the slides were made by Analyst A.

‡ In this instance the agar plates were counted by Analyst C, while the slides were counted by Analyst A.

TABLE LVIII.— SERIES A, SAMPLE No. 15. MILK SOURING NORMALLY WITH *Bact. lactis acidi*. SOME SAMPLES CURDLED BEFORE THEY WERE EXAMINED.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*....	2,300,000,000	900,000,000	1,300,000,000	The bacteria in the microscopic preparations were so thick that it was impossible to make more than a rough estimate of numbers. Only small portions of five fields were counted in any case. No clumps containing more than four bacteria were seen. The average group contained 1.8 individuals.
I-I......	1,900,000,000	1,400,000,000	2,400,000,000	
B-B.....	2,100,000,000	670,000,000	1,800,000,000	
B-D.....	1,500,000,000	1,200,000,000	1,800,000,000	
C†-C‡....	2,000,000,000	2,500,000,000	3,300,000,000	
C†-B....	2,000,000,000	?	1,600,000,000	
D-D.....	2,100,000,000	?	1,900,000,000	
D-C‡....	2,000,000,000	?	3,800,000,000	
G-G.....	3,200,000,000	1,870,000,000	4,300,000,000	
G-E.....	3,100,000,000	2,700,000,000	5,400,000,000	
E-E.....	903,000,000	1,700,000,000	3,500,000,000	
E-G.....	780,000,000	1,600,000,000	2,000,000,000	
I-I......	2,000,000,000	720,000,000	1,400,000,000	
I-F......	1,800,000,000	1,600,000,000	3,000,000,000	
Averages..	2,000,000,000	1,500,000,000	2,700,000,000	

* The first analyst named made the agar plates and microscopic slides. The second named counted the plates and slides.

† In this instance the plates were made by Analyst C, while the slides were made by Analyst A.

‡ In this instance the agar plates were counted by Analyst C, while the slides were counted by Analyst A.

TABLE LVIX.— SERIES A, SAMPLE No. 16. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*	69,000	15,000	63,000	Clumps containing 10 or more bacteria were relatively common, all analysts reporting 10 or more. The largest clump noted contained 150 individuals. The average group contained 6.4 individuals.
F-I	79,000	95,000	615,000	
B-B	89,000	87,000	501,000	
B-D	?	78,000	580,000	
C†-C**	98,000	96,000	900,000	
C†-B	100,000	54,000	222,000	
D-D	76,000‡	66,000	765,000	
D-C**	?	48,000	360,000	
G-G	109,000	30,000	275,000	
G-E	120,000	69,000	106,000	
E-E	202,000	131,000	412,000	
E-G	172,000	40,000	425,000	
I-I	184,000	27,000	122,000	
I-F	150,000	9,000	68,000	
Averages	121,000	60,000	387,000	

* The first analyst named made the agar plates and the microscopic slides. The second analyst named counted the plates and slides.

** In this instance the agar plates were made by Analyst C, while the microscopic slides were made by Analyst A.

† In this instance the plates were counted by Analyst C, while the slides were counted by Analyst A.

‡ Count made at the end of five days. After seven days incubation the plates were covered with innumerable tiny colonies evidently a contamination.

TABLE LX.— SERIES A, SAMPLE NO. 17. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*....	25,000	9,000	33,000	The larger number of clumps seen which contained 10 or more individuals were of long chain streptococci. One very large mass of bacteria was seen by Analyst F. Analyst A reported two clumps which included 32 and 160 individuals, respectively. Analyst B reported one clump of 22 individuals. Analyst D saw six clumps including 150, 50, 16, 18, 60, and 30 individuals, respectively. Analyst I saw groups of 10 or more bacteria but did not record their exact size. The average group contained 18.0 individuals.
F-I......	30,000	13,000	19,000	
B-B.....	9,300	6,000	69,000	
B-D.....	?	3,000	6,000	
C†-C‡....	11,000	18,000	600,000	
C†-B....	14,000	12,000	250,000	
D-D.....	7,000	33,000	830,000	
D-C‡....	6,800	21,000	63,000	
G-G.....	30,000	Less than 5,000	Less than 5,000	
G-E.....	32,000	13,000	13,000	
E-E.....	28,000	30,000	114,000	
E-G.....	28,000	Less than 5,000	Less than 5,000	
I-I......	39,000	11,000	146,000	
I-F......	33,000	6,700	1,140,000	
Averages..	23,000	13,000	234,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the plates and the slides.

† In this instance the plates were counted by Analyst C, while the slides were counted by Analyst A.

‡ In this instance the agar plates were made by Analyst C, while the microscopic slides were made by Analyst A.

TABLE LXI.— SERIES A, SAMPLES No. 18. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*....	500	5,000	7,500	Analyst A reported that he found 32 bacteria in a clump attached to a dirt particle, while Analyst D reported one clump of 10 and one clump of 11 individuals. Apparently no other groups as large as these were seen.
F-I......	500	10,000	19,000	
B-B.....	2,000	3,000	3,000	
B-D.....	?	18,000	51,000	
C†-C‡....	5,000	12,000	111,000	
C†-B.....	3,000	9,000	78,000	
D-D.....	970	60,000	140,000	
D-D‡....	700	6,000	6,000	The average group contained 2.7 individuals.
G-G.....	3,000	20,000	30,000	Too great dilution was used by all analysts in making the agar plates, so that these were very unsatisfactory.
G-E.....	4,000	6,000	6,000	
E-E.....	1,100	Less than 6,000	Less than 6,000	
E-G.....	1,200	Less than 5,000	Less than 5,000	
I-I.......	1,600	11,000	19,000	
I-F......	1,000	7,000	11,000	
Averages..	1,900	12,000	34,000	

* The first analyst named made the agar plates and microscopic slides. The second analyst named counted the plates and slides.

† In this instance the plates were made by Analyst C, while the slides were made by Analyst A.

‡ In this instance the agar plates were counted by Analyst C, while the slides were counted by Analyst A.

TABLE LXII.— SERIES A, SAMPLE NO. 19. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*....	14,800,000	11,400,000	22,000,000	Numerous clumps were found in the microscopic preparations which contained more than 10 and less than 50 individuals. The average group contained 3.3 individuals.
F-I......	10,000,000	6,000,000	21,000,000	
B-B.....	8,500,000	6,300,000	29,000,000	
B-D.....	?	4,700,000	35,000,000	
C†-C‡....	7,600,000	4,200,000	20,000,000	
C†-B....	8,800,000	4,700,000	25,000,000	
D-D.....	8,500,000	8,800,000	29,000,000	
D-C‡....	8,000,000	5,200,000	27,000,000	
G-G.....	12,000,000	3,300,000	16,000,000	
G-E.....	12,000,000	17,500,000	35,000,000	
E-E.....	18,000,000	24,000,000	86,000,000	
E-G.....	13,000,000	1,200,000	6,300,000	
I-I.......	15,000,000	11,000,000	23,000,000	
I-F......	15,000,000	9,300,000	23,000,000	
Averages..	12,000,000	8,400,000	28,000,000	

* The first analyst named made the agar plates and the microscopic slides. The second analyst named counted the plates and the slides.

† In this instance the agar plates were made by Analyst C, while the slides were made by Analyst A.

‡ In this instance the agar plates were counted by Analyst C, while the slides were counted by Analyst A.

TABLE LXIII.— SERIES A, SAMPLE 20. ITHACA MARKET MILK KEPT ON ICE FOR 24 HOURS.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
F*-F*....	5,800,000	5,100,000	35,000,000	This milk contained numerous clumps of bacteria containing ten or more individuals and each analyst reported finding them. The average group contained 5.0 individuals.
F-I......	5,500,000	3,200,000	22,000,000	
B-B......	4,800,000	2,500,000	14,000,000	
B-D......	?	3,500,000	43,000,000	
C†-C‡....	1,400,000	2,600,000	16,000,000	
C†-B.....	1,900,000	3,600,000	18,000,000	
D-D.....	2,900,000	4,800,000	55,000,000	
D-C‡.....	2,300,000	7,500,000	27,000,000	
G-G......	9,500,000	1,600,000	14,000,000	
G-E......	9,500,000	13,000,000	28,000,000	
E-E......	6,300,000	10,000,000	24,000,000	
E-G......	6,100,000	3,200,000	22,000,000	
I-I.......	8,800,000	3,900,000	21,000,000	
I-F.......	8,400,000	4,000,000	22,000,000	
Averages..	5,600,000	5,200,000	26,000,000	

* The first analyst named made the agar plates and the microscopic slides. The second analyst named counted the agar plates and slides.

† In this instance the plates were made by Analyst C, while the slides were made by Analyst A.

‡ In this instance the plates were counted by Analyst C, while the slides were counted by Analyst A.

TABLE LXIV.— SERIES B, SAMPLE No. 1. MILK FROM A SINGLE COW DRAWN INTO A STERILE COVERED PAIL.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
B*-B*....	1,010	12,000	18,000	As the men who were most experienced in examining microscopic preparations of milk only found 4 single bacteria and 2 pairs of bacteria in examining 1200 microscopic fields, and as all analysts agreed that the agar plate count was very low, it seems probable that the higher microscopic "counts" reported by the less experienced men were based on counts of objects other than bacteria. The average group contained 1.3 individuals.
B-D......	560	Less than 3,000	Less than 3,000	
C-C†.....	273	Less than 3,000	Less than 3,000	
C-B......	570	Less than 3,000	Less than 3,000	
D-D.....	320	3,000	3,000	
D-C†	285	3,000	3,000	
F-F......	255	258,000†	300,000†	
F-I.......	290	156,000†	192,000†	
H-H.....	340	75,000†	92,000†	
H-F	360	92,000†	107,000†	
I-I.......	220	42,000†	53,000†	
I-H......	190	25,000†	28,000†	
Averages..	390	3,000	4,000	

* The first analyst named made the agar plates and the microscopic slides. The second analyst named counted the plates and the slides.

** In this instance the agar plates were counted by Analyst C, while the slides were counted by Analyst A.

In this instance the agar plates were made by Analyst C, while the slides were made by Analyst A.

† Omitted from the average as these "counts" are evidently too large.

TABLE LXV.— SERIES C, SAMPLE No. 1. MILK FROM A SINGLE COW DRAWN INTO A STERILE COVERED PAIL.

Analyst.	Plate "count."	Group "count."	Individual "count."	Notes.
B*-B*....	530	6,000	15,000	The milk used for these analyses was from the same cow as that used for the analyses given in Table LXII. The greater regularity in the microscopic "counts" in the present table is undoubtedly due to the greater experience of the analysts with the microscopic technique. The average group contained 1.3 individuals.
B-CH....	580	9,000	9,000	
C†-CA...	1050	3,000	3,000	
C†-EI....	1010	Less than 3,000	Less than 3,000	
E-E......	620	27,000	30,000	
E-BF....	590	3,000	6,000	
F-F......	520	3,000	6,000	
F-HE....	450	Less than 3,000	Less than 3,000	
H-H.....	567	6,000	6,000	
H-IB.....	563	Less than 3,000	Less than 3,000	
I-I.......	493	Less than 3,000	Less than 3,000	
I-FA.....	500	9,000	12,000	
Averages .	623	5,500	7,250	

* The first analyst named made the agar plates and microscopic slides. Where a single letter is found in the second column of letters it signifies that both the plates and slides were counted by the analyst designated. Where two letters are given, the first analyst designated counted the plates while the second analyst counted the microscopic slides.

† In this instance the agar plates were made by Analyst C, while the slides were made by Analyst A.

TABLE LXVI.— SERIES A. FINAL SUMMARY OF PLATE AND MICROSCOPIC "COUNTS."

Sample no.	Plate "count."	Group "count."	Individual "count."	Ave. size group	Notes.
1......	10,600	18,700	103,000	5.5	Herd milk.
2......	10,400	19,600	92,000	4.7	Herd milk.
3-5....	6,000	5,000	15,000	3.0	Herd milk.
4......	45,000	41,000	145,000	3.5	Herd milk.
6......	78,000	46,000	185,000	4.0	Market milk.
7......	72,000	47,000	202,000	4.3	Market milk.
8......	30,000	51,000	189,000	3.7	Market milk.
9......	98,000	80,000	383,000	4.8	Market milk.
10.....	285,000	94,000	721,000	7.7	Market milk.
11.....	.. 52,000,000	93,000,000	99,000,000	1.06	Inoculated with long-rod, lactic acid organism.
12.....	48,000,000	49,000,000	67,000,000	1.4	Inoculated with the colon bacillus.
13.....	135,000,000	37,000,000	163,000,000	4.4	Fresh milk incubated at 37° C. for 24 hrs.
14.....	9,900,000	5,900,000	150,000,000	25.4	Market milk known to contain streptococci.
15.....	2,000,000,000	1,500,000,000	2,700,000,000	1.8	Milk nearly curdled containing *Bact. lactis acidi*
16.....	121,000	[illegible]0,000	387,000	6.4	Market milk.
17.....	23,000	13,000	234,000	18.0	Market milk found to contain streptococci.
18.....	1,900	12,000	34,000	2.7	Market milk.
19.....	12,000,000	8,400,000	28,000,000	3.3	Market milk.
20.....	5,600,000	5,200,000	26,000,000	5.0	Market milk.
21.....	390	3,000	4,000	1.3	Milk from single cow.
22.....	623	5,500	7,250	1.3	Milk from single cow.

a. AGAR PLATE COUNTS

Technique used.—Each of the seven analysts (three from Geneva, three from Ithaca, and one a Geneva man working at the time at Ithaca) was instructed to prepare his own materials, and to use whatever procedure he felt would give the most accurate "counts." Naturally, these instructions resulted in great diversity of method, a fact which should be kept in mind in considering the harmony of results.

It is neither possible nor important to specify all of the minor differences in technique. All used a prolonged incubation at two or more temperatures. Some accomplished the result by first incubating the plates at 20° C. for five days followed by two days of incuba-

tion at 37° C. Others went to the work of preparing two, or even three, sets of plates from each sample which were then incubated at two or three different temperatures. In the latter cases, the highest "counts" were regarded as the most accurate, and were the ones which were returned in the final reports.

The four Geneva men (B, C, D, and E) used an agar containing 1 per cent Witte's peptone, 0.5 per cent Liebig's beef extract, and 1.5 per cent air dried agar, while all of the others used agar of similar composition except that lactose or a mixture of lactose and dextrose was added. One (G) added Difco peptone as well as Witte's peptone, while one (F) used a whey agar. The latter, however, was used only for the first lot of samples as in this instance (Table XLVIII) very low counts were obtained.

Some clarified their agar with dried egg albumen, others with fresh eggs, while others did not clarify. In some cases the reaction of the medium was adjusted after titration with phenolphthalein, while in others it was not adjusted. It is worth noting that the man (G) who used the agar with the most complicated formula (containing both kinds of peptone and both lactose and dextrose) frequently obtained counts decidedly larger than the other analysts.

Four men (B, C, D, and E) used pipettes with a single graduation mark. Three of these men (B, D, and E) merely emptied these pipettes without rinsing and later it was found that these pipettes did not deliver a full cc. when used in this way. The others used pipettes with two graduation marks. All used three different dilutions in preparing the plates as the probable "count" was unknown; and all made at least three plates from each dilution. Even with these precautions, all plates were overcrowded with colonies in some cases (especially Sample No. 15), while in others even the lowest dilution gave so few colonies that the "count" was felt to be unreliable (especially Sample No. 18).

All petri plates were recounted by a second analyst from the laboratory in which the plates were made. All "counts" were computed independently by each analyst and sent to a central office for comparison. Later, when these results were compared, errors of computation, some of large size, were found and eliminated. Scarcely any one of the analysts escaped making these errors, showing that they are not uncommon.

It might be well to add at this place also that, when the authors of this report checked over the results published in their preliminary account[1] with a calculating machine, some minor errors were found. While it is probable that errors have been reduced to a minimum in the present report thru the use of a calculating machine yet, in spite of the care taken, it is improbable that the fallibility of man has been entirely overcome.

[1] See footnot on p. 148.

Counts obtained.— An examination of the summary table (Table LXVI) will show the size of the average "counts" obtained from each sample. The miscellaneous character of the samples is shown by the fact that five samples (Nos. 3, 5, 18, 21, and 22) gave "counts" well within the limits prescribed for certified milk. Five additional samples (Nos. 1, 2, 4, 8, and 17) gave "counts" less than the 60,000 limit prescribed in the State Sanitary Code[1] for Grade A raw milk. Four others (Nos. 6, 7, 9, and 16) gave "counts" in excess of 60,000 but less than the 200,000 limit prescribed for Grade B raw milk. Of the remaining market milk samples, three (Nos. 10, 19, and 20) would necessarily fall into the Grade C class as they gave a "count" in excess of 200,000. Samples Nos. 11, 12, 13, 14, and 15 also gave very high "counts," as was expected from the methods of preparation used. The series as a whole, therefore, included fresh milk of all grades and of a truly representative character.

The detailed records will be found in Tables XLI to LXV. In examining these it has been found that 12 of the maximum "counts" were made by Ithaca analysts (F, G, and I), and seven by Geneva (B, C, D, and E) analysts. On the other hand, 18 out of 19 of the minimum "counts" were reported by Geneva men. This discrepancy caused an investigation of possible reasons which led to the use of a common lot of agar containing lactose with a consequent improvement (Series B), but not an entire elimination of this tendency to secure low "counts" at Geneva. This tendency later entirely disappeared (Series C) with a standardization of the methods used in preparing the dilution waters and the more thoro rinsing of the one mark pipettes.

Even a casual examination of the "counts" given in Tables XLV to LXV will show that these results are more variable than are those which were obtained from Series B and C. A fair comparison can be made for example between the results reported for Sample No. 10 in Series A (Table LIII) with the results obtained from Samples Nos. 2, 3, and 4 in Series B (Table XIX). Altho the final average "count" for Sample No. 10, Series A is 285,000, one of the 12 "counts" from which this average is computed is as low as 137,000, while the highest "count" is 427,000. On the other hand, while the average "count" for Samples Nos. 2, 3, and 4, Series B, is 346,000, the lowest of the 36 "counts" included in the average is 301,000, while the highest is 420,000.

Even the results secured from the samples containing a miscellaneous flora, which were included in Series B and C (see Tables LXIV and LXV), were more regular than those obtained from Sample No. 18 (Table LXI). All of these were very high grade fresh milk, containing very small numbers of bacteria.

[1] The Sanitary Code established by the Public Health Council of the State of New York Chapter III, Milk and Cream, 1914.

The latter comparison indicates that the greater regularity in results secured in Series B and C was partially due to the improvement in, and standardization of the technique. Much, however, of the regularity of Series B and C is evidently due to the fact that the bacterial flora was of a type that favored regular results.

It should be noted, in conclusion, that even the irregular "counts" from Series A, secured as they were by unstandardized and quite variable technique, are more regular than the " counts " which were reported by Conn[1] in which a standardized, but simplified routine technique was used (Breed and Stocking).[2]

b. MICROSCOPIC COUNTS

Technique used.—Only three of the men who participated (A, B, and D) in these analyses had ever previously attempted to make microscopic "counts" from a series of samples. Duplicate microscopic preparations were made from each sample, which were usually recounted by a second analyst. One hundred fields of the microscope were counted in many cases, but where the bacteria were numerous this was impracticable. The experienced men adjusted their microscopes so that the amount of milk examined in each field was 1/300,000 cc. The inexperienced men usually used a higher magnification, and did not adjust their microscopes so as to get a simple factor for multiplication. In some cases the factor used was not recorded, and there being no record of the number of bacteria or groups of bacteria seen, it was impossible to determine the amount of milk actually examined per field. It probably was between 1/500,000 and 1/300,000 cc. in all cases.

Counts obtained.—In view of the conditions under which these microscopic "counts" were made, it is not surprising to find that they are variable and evidently inaccurate in many cases. The most regular of the "counts" were obtained from Samples Nos. 11 and 12 (Tables LIV and LV), where the conditions favored this type of counting.

The most significant of the results secured from the microscopic examination were data regarding the size of the groups of bacteria that were present in these miscellaneous samples. The average size of these groups is given in the 5th column of the summary Table LXVI. From this record it will be seen that the average number of individuals per group varied in the 21 samples from 1.06 to 25.4; or from 2.7 to 18.0 in the 17 samples which may be regarded as typical of ordinary herd or market milk. These average figures, moreover, do not tell the whole story, for they do not show the range of variation in size of clumps. This is indicated roughly by

[1] See footnote on p. 146.

[2] See footnote on p. 148.

the "notes" given with Tables XLV to LXV. In these are indicated the number of groups per sample which contained 10 or more individuals. These records are, however, incomplete as the analysts did not always record the presence of groups of this size.

It will be seen from these notes that the largest groups were found in Sample No. 13 (Table LVI) which was a high grade milk incubated at 37° C. for 24 hours before it was used. The large groups were in reality minute compact colonies containing thousands of individual bacteria, and all of the largest groups were of micrococci presumably of udder origin. Apparently but one of the analysts chanced to find any of the large groups in the fields examined and counted. However, all of the men noted the presence of these masses of bacteria, as they were large enough to be readily visible even under a low power lens. The large sized groups probably broke apart to quite an extent in making the dilutions for the agar plates, as the group "counts" from this sample are usually much smaller than are the agar plate "counts." Because of the fact that there were also many isolated bacteria and small clumps present, the average group in this sample contained only 4.4 individuals.

The largest average size of group was found in Sample No. 14. This milk was prepared by mixing about equal quantities of herd milk and of milk from a cow whose udder was known to be infected with streptococci. In this way milk was secured which was practically identical in appearance with numerous samples of streptococcus-infected milk found in the microscopic examination of Geneva market milk. Practically no bacteria were present in this milk other than long chain streptococci, and few of the chains contained less than 10 individual cocci. As some groups contained hundreds of cocci and as they were very unevenly distributed in the microscopic preparations it is not surprising to find that the "counts" of individual bacteria varied from 61,500,000 per cc. to 302,700,000 per cc. The plate "counts" were inclined to be low and scarcely larger than the group "counts," tho the fact that one analyst (G) succeeded in getting agar plate "counts" with much larger numbers of colonies on them than did the other men raises the suspicion that the agar used by this man was more suited for growing streptococci than the agars used by the other men. It seems likely from this that the low agar plate "counts" were caused as much by the failure of the organisms to grow as by the clumping in masses.

As it may be contended that Sample No. 14 really was abnormal in character it is worth noting that one of the 10 samples of Ithaca market milk, picked out at random without any knowledge as to its probable flora, also contained large numbers of long chain streptococci. This sample (No. 17) contained a mixed flora in addition to the streptococci, so that, whereas the chains of streptococci were fully as long

as those in Sample No. 14, the average group contained only 18.6 individuals. The effect of the presence of these masses of bacteria on the "counts" from Sample No. 17 was similar to that noted for Sample No. 14. The individual "counts" were very irregular, varying from less than 5,000, in the case of one analyst who did not chance to find any bacteria, to 1,140,000 per cc. in the case of another analyst who chanced to find a relatively large sized group. The agar plate "counts" for this sample are likewise irregular, and all of the analysts who used an agar containing lactose secured "counts" which were decidedly larger than those obtained by the analysts who used an agar containing no sugar. This indicates, as before, that the failure of some of the organisms to grow helped to cause discrepancies in the "counts."

As a contrast to the "counts" from the samples which contained large masses of bacteria, the "counts" from Samples Nos. 11 and 12 are instructive. Sample No. 11 was inoculated with an organism of the bulgaricus group known to grow poorly on ordinary agars, and to form very tiny colonies. Likewise it was known to be a large rod which usually occurred in milk as isolated individuals. As was expected, the individual microscopic "counts" were scarcely larger than the group "counts." The microscopic "counts" were more irregular than might have been expected from the even distribution of the bacilli in the milk; but this was due apparently to the fact that, whereas the granules in the rods stained well, the rods themselves stained poorly in the methylene blue. As some rods contained few or no granules, they were easily overlooked. In other cases the granules were so deeply stained and so regular in size that one analyst (the man who had originally isolated and studied this culture) mistook the granules for chains of cocci, and counted the individual granules instead of the rods. When this was discovered a recount was made. These things are mentioned merely to show how difficult it is to interpret bacterial " counts " of any sort without a knowledge of all of the significant facts.

The agar plate "counts" from this sample were also irregular, one analyst merely reporting a "count" of the extraneous colonies other than the tiny, almost microscopic, colonies. The others attempted to estimate the numbers of the tiny colonies present, but evidently failed to find all that probably were present in many cases.

Sample No. 12 was of milk inoculated with a colon organism, and the regularity of the "counts" secured was responsible for the use of similar samples in Series B and C. Both microscopic slides and agar plates presented very favorable conditions for regular and accurate counting.

Sample No. 15 gave simply enormous "counts" both by the plate and by the microscopic methods. This was a butter starter taken

just as it curdled. In fact, some of the samples curdled during the process of preparing them for the plates and slides, thereby making it impossible to get accurate counts. The results given are really very crude estimates of numbers, regardless of the method used, and are remarkable for their regularity under these conditions. The agar plates from which the "counts" were made contained from one to three thousand colonies, and these "counts" are doubtless too low. The bacteria in the microscopic preparations were so numerous that they overlaid one another. It was, therefore, impossible to count even one microscopic field accurately, and the most that was done was to count portions of one to five fields, and make estimates of the numbers present in the whole field. Because of the even distribution of the bacteria, these estimates were more regular than might have been expected. As the bacteria were practically all *Bacterium lactis acidi*, the average group contained few individuals.

At the time that these "counts" were made, it was felt that, for some reason, a very unusual butter starter had been selected which contained more bacteria than are normally present in uncurdled milk. Later work, now in process of publication[1] has shown, however, that milk souring with a normal lactic acid fermentation invariably develops billions of bacteria per cc. before curdling occurs.

If the microscopic "counts" from the remaining samples are examined in equal detail, it will be seen that they present intermediate conditions between the more regular results obtained from the samples containing the evenly distributed and usually isolated bacteria and the more irregular results from the samples containing the long chain streptococci. In other words, the results of these microscopic "counts" show clearly that conditions in the samples themselves may play a large part in determining whether accurate "counts" can be made.

C. COMPARISON BETWEEN THE AGAR PLATE AND MICROSCOPIC COUNTS

The most important results secured from the comparison of the two types of counts have already been indicated in the discussion of the microscopic "counts." In almost every case where marked discrepancies in the two types of "counts" were found, it was possible to find a reasonable explanation of the discrepancy. Thus, sometimes the microscopic examination revealed the presence of masses of bacteria of such compact nature that they undoubtedly failed to break up completely. In other cases, the plates themselves gave evidence that some of the living bacteria had failed to develop into colonies. In general, however, it was the occurrence of the

[1] Baker, J. C., Brew, J. D. and Conn, H. J. Relation between lactic acid production and bacterial growth in the souring of milk. N. Y. Agr. Exp. Sta., Tech. Bul. 74. 1919.

bacteria in groups which apparently caused the plate "counts" to be less than the probable number of bacteria present.

The average plate "counts" were larger than the group "counts" in 13 of the 21 samples (see Table LXVI). In no case did the plate "count" exceed the individual "count" made from the same sample. Thus the plate "counts," ordinarily, were intermediate in size between the two microscopic "counts," as was to be expected from theoretical considerations.

DISCUSSION AND CONCLUSIONS

The results secured indicate that skilled analysts, using proper technique, ordinarily obtain reasonably accurate estimates of the number of living bacteria in cubic centimeter samples of milk by the plate method *provided* the milk contains isolated organisms of a type capable of growth on agar under the conditions maintained.

They likewise indicate that estimates of the numbers of living bacteria and of the groups of bacteria can be made with equal accuracy by direct microscopic examination *provided* there are neither large clumps of bacteria nor dead bacteria present.

These statements are based on the fact that, under the favorable conditions maintained in Series B and C, six analysts obtained "counts" or "estimates" of the number of bacteria from duplicate samples of milk by the use of the agar plate technique and by direct microscopic examination which showed good agreement among themselves, which had a coefficient of variability under 15, and which met all other checks upon their accuracy in such a way as to establish their true accuracy with reasonable certainty.

Because of the presence of clumps of bacteria, the agar plate "counts" were in each case less than the true number of individual bacteria present.

It being self evident that these accurate estimates were obtained under conditions much more favorable than those ordinarily present, the question naturally arises whether the inaccuracies in "counts" under ordinary conditions are sufficient to destroy the value of bacterial determinations. This question cannot be answered with entire satisfaction even with the data gathered in this and in previous investigations; but certain facts are evident as the result of the work done on the series of miscellaneous samples.

There has been a general feeling in the past that the errors in plate "counts" which were of the greatest significance were those introduced thru the failure to prepare media of the correct reaction or composition, thru the failure to use proper incubation temperatures, or thru spreading colonies, overcrowding of colonies, and the like. Much attention has been given to the standardization of technique in order to reduce the known difficulties to a minimum.

Nevertheless, it does not seem probable that the errors caused by these things are so generally present or so irregular as those caused by the occurrence of the bacteria in groups of different average sizes. As is clearly evident from Series A, it is not at all uncommon to find that one milk contains bacteria occurring in groups averaging two individuals per group, while another contains bacteria occurring in groups averaging four, six or even more individuals. Large errors in count caused in this way must be the rule rather than the exception. The latter errors could be eliminated if some method could be devised whereby the groups could be broken into their component individuals before the plates were prepared, and recent discussions of the plating technique emphasize the necessity of shaking the samples in a standardized way. Bacteria have so little weight, however, in proportion to their surface that hand shaking can have but little effect upon the compact clumps.

The most disquieting feature of the errors introduced by the clumping of the bacteria is the fact that they may be highly variable, and yet pass undetected. It is reassuring to secure a series of plate "counts" from duplicate samples of milk which are in close agreement; and especially so if the analyses are made in different laboratories. However, the feeling that the "counts" are accurate passes away at once as soon as microscopic studies are made, and it is found probable that some of the "counts" are affected by a 100 per cent error, others by a 200 per cent error, and still others by a 1,000 per cent error, none of which are indicated in any way in the plate "counts."

It is natural to feel that a milk sample giving a plate "count" of 40,000 per cc. actually contains fewer bacteria than a milk sample giving a plate "count" of 50,000 per cc. Yet comparative studies indicate that the chances are at least as great as one out of three that milk giving a plate "count" of 50,000 actually contains fewer bacteria than milk giving a plate "count" of 40,000. The chance that the lower "count" signifies larger numbers of bacteria becomes less and less as the margin between the "counts" becomes greater. If one can judge from the records already available giving the average size of the groups of bacteria in miscellaneous samples of milk, a margin of one to five is usually sufficient to eliminate any chance that the lower "count" represents the greater number of bacteria; but even this margin does not appear to be sufficient to cover the errors introduced thru the clumping of streptococci.

In contrast to these errors in plate "counts," caused by the difficulties involved in devising a perfect technique, the greatest difficulties met with in making accurate microscopic "counts" are those which involve the skill and patience of the analyst. Thus, in the present work, it was not until the last series of analyses were made that the men without previous experience realized these limi-

tations of the microscopic technique, and not until then did the work of all of the men begin to have precision and accuracy. In this series (C) the coefficient of variability of the microscopic "counts" was reduced to a figure comparable with that obtained from the plate "counts," i. e., less than 15.

Because the "counts" were made by two methods, it was ordinarily possible to detect conditions unfavorable to accurate work. Thus the microscope always showed what the conditions really were in regard to the size of the groups and the types of bacteria present, while the agar plates showed the number of centers of growth capable of development under the conditions maintained. Gross discrepancies in the "counts," not explainable thru the presence of clumps, suggested the presence of dead bacteria, or of living bacteria not capable of growth on the plates. The fact that interpretations of this sort were possible shows that it would be an excellent practice for analysts to make "counts" of both sorts wherever especially accurate results are desired. Under such conditions, care should be taken to make the "counts" by more precise methods than those used in ordinary routine work.

No attempt has been made in the present work to measure the inaccuracies introduced thru the use of simplified or careless procedures. It is self evident, however, that reduction in the number of agar plates per sample, reduction in the number of dilutions used, the use of a single high temperature for incubation, rapid counting of plates by a single person, or even rapid computation of final results introduce chances of error.

Likewise, in making microscopic examinations, large errors in counts may be caused by inaccurate calibration of pipettes, incorrect standardization of the microscope, poor preparations, lack of care and experience in the examination of the slides, and mistakes in counting and computation of results.

Some idea of the inaccuracies introduced by the use of a simplified agar plate technique may be gained by comparing the results secured in Series A with those secured in the series of analyses discussed by Conn.[1] There is no method by which really satisfactory comparisons can be made in this case; but a mere examination of the regularity of the results will show that there is much less harmony in the results secured by the rapid routine methods.

The evident inaccuracies in the latter "counts" are so great that several bacteriologists have raised the question whether bacteriological counting methods can be made sufficiently accurate to justify their use in grading milk. The authors of the present report feel, however, from the results obtained, that the methods we now have can be used with sufficient accuracy to satisfactorily separate milk into as many as three or possibly four grades on the basis of the

[1] See footnote on p. 146.

number of bacteria present. This may well be true even tho neither the agar plate nor the direct microscopic method can be made to yield accurate counts of the individual bacteria present when used to examine large numbers of miscellaneous samples of market milk.

As a matter of fact, the necessity for exact counts is frequently overemphasized. Exact counts are really of little importance in grading milk. The man who takes in the milk at a receiving station can make much use of information telling him the grade of milk that he is handling, and can make little greater use of information showing that John Smith's milk gave a plate "count" of 79,000 per cc., while Peter Johnson's gave a "count" of 53,000. Likewise, the control official is more interested in the approximate number of bacteria showing the grade of milk supplied by any particular dealer, than he is in knowing that a given sample of milk gave a plate "count" of 42,000 per cc.

In many places exact information regarding the number of colonies developed on agar plates per cc. of milk can be used to good advantage, but it is dangerous information to put in the hands of men who do not understand the limitations of this technique. For the purpose of grading milk into three or four classes, exact information as to the number of individual bacteria present is no more essential than is a knowledge of the exact number of trees per acre of woodland to an aviator in order that he may distinguish between wooded areas, partially wooded areas, and treeless areas. Yet the latter knowledge is all that he needs in order to select a treeless area in which to make a safe landing.

The proof that milk grading can be carried out with a fair degree of accuracy without making exact counts is not yet extensive, and this matter should be tested much more completely than it has been. Some data have been reported by Breed and Brew[1] which may be summarized briefly as follows:

a. Two analysts working under commercial conditions in a laboratory maintained by one of the large New York City milk distributing companies agreed in their classification of 1339 out of 1504 miscellaneous samples of unpasteurized milk into two classes where one analyst used the microscopic and the other the agar plate technique. This was an exact agreement in grade of 89.03 per cent, tho the technique used both for the microscope and agar plates was of a simplified character.

b. When conditions were made more severe thru a division of the milk into three classes, in place of two, and one analyst made both examinations by more careful methods, an exact agreement in grade was secured in 587 out of 643 samples (91.29 per cent of agreement).

It is evident that, wherever harmony in results was secured, it is

[1] Breed, R. S. and Brew, J. D. The control of bacteria in market milk by direct microscopic examination. N. Y. Agr. Exp. Sta., Bul. 443. 1917.

probable that the milk was correctly graded. Wherever the grades did not agree, the milk must have been incorrectly placed by one or the other technique. The fact that a significant percentage of error was found where the milk was separated into only three classes with careful technique indicates that large percentages of error in grade must occur where the attempt is made to separate the milk with less accurate technique into larger numbers of classes. It is manifestly absurd to attempt to grade milk into a larger number of classes than the accuracy of the analytical methods will justify. Wherever methods are abbreviated, there always arises the danger of sacrificing accuracy.

Further comparative analyses of the type just reported should be made at once as the problem is an important one to New York State dairymen. The principle of paying for milk on the basis of quality is fundamentally correct, and everything possible should be done to foster this custom.

THE REACTION OF MILK IN RELATION TO THE PRESENCE OF BLOOD CELLS AND OF SPECIFIC BACTERIAL INFECTIONS OF THE UDDER *

J. C. BAKER† AND R. S. BREED

SUMMARY

1. Samples of fresh milk drawn aseptically from separate quarters of the udder have been studied to determine their true reaction, the number of leucocytes present, the amount of epithelial cell debris, and the presence or absence of streptococci. The samples were obtained from animals in three separate herds, including Jerseys, Holsteins, and grade Holsteins.

2. A fairly close relationship has been found to exist between decreasing hydrogen ion concentration of the fresh milk and increase in numbers of leucocytes. Samples containing large numbers of leucocytes usually, tho not invariably, contained streptococci as well. The less acid milks were also found to contain an irregularly increasing amount of epithelial cell debris.

3. These conditions, combined with the chemical relationships, support the idea that the decreased hydrogen ion concentration is caused primarily by the entrance of the alkaline substances of the blood into the milk; and that, accompanying this entrance of alkaline substances, there is a partial entrance of the other substances found in blood serum. The entrance of wholly unchanged serum, however, does not appear to occur until actual disintegration of the tissues begins.

4. From the biological standpoint, the conditions can be explained in the majority of the samples examined by assuming that this entrance into the milk of only partially elaborated blood serum is caused by the streptococcic infection. Accompanying this serous exudate, there would very naturally be an increased entrance of leucocytes thus explaining the relationship between the reaction and the numbers of leucocytes noted above. As the process continued the epithelial cell debris would increase by disintegration of the glandular epithelium.

* Reprint of Technical Bulletin No. 80, July 1920. Also appears in condensed form in Jour. Biol. Chem. 43, 221-235. 1920.

† Formerly Associate Chemist at this Station.

INTRODUCTION

In a previous bulletin[1] it has been shown that certain relations exist between the reaction of apparently normal milk and its chemical composition, and brief reference is made to the relation between the reaction of milk and the presence of leucocytes and streptococci. In conclusion, it is stated that the conditions are such that they support the idea that the low hydrogen ion concentration occasionally found in freshly drawn milk is due to the presence of blood serum in the milk. Because of the importance of this suggestion in explaining bacteriological and physiological problems, the biological data that have a bearing on this theory are discussed in the present bulletin.

It is well known that under abnormal conditions, not only blood serum, but blood itself may enter without change into milk as secreted. In some cases, the blood enters because of hemorrhages due to injury or natural rupture of blood vessels, but in other cases the blood enters because of pathological conditions that are caused by specific bacterial infections. The commonest of the pathogenic organisms that cause the breaking down of the glandular tissue are the pathogenic streptococci, and this type of infection is the only one that has been studied during the present investigation. It should not be forgotten, however, that pathogenic staphylococci, organisms of the colon group, *Bacillus pyogenes*, the organism of bovine tuberculosis, and species of *Actinomyces* have all been described as causing similar infections.[2] Recently, attention has been called to infections of the udder with *Bacterium abortus*.[3]

It has been abundantly established by a comparison of the composition of blood serum and of normal milk that the nutrient materials of the latter are quite different from those of the former. Normal milk solids are the products of the secretory activity of the glandular epithelium. The cells in this epithelium secure their raw materials from the blood serum, or more directly from the lymph, and transform them into the fats, casein, lactose, and other solids of the milk. Few substances other than water and some of the mineral salts pass unchanged into milk during normal secretion.

The situation in regard to the formed elements in the blood such as the red and white corpuscles differs from that just discussed. The red cells do not pass into the milk under normal conditions, while leucocytes have been shown to be so universally present that they must be regarded as a normal constituent of market milk.[4] The

[1] Van Slyke, L. L. and Baker, J. C. Conditions causing variation in the reaction of freshly-drawn milk. N. Y. Agr. Exp. Sta. Tech. Bul. 70. 1919.

[2] Wall, S. translated by Crocker, W. J. Mastitis of the cow. Philadelphia: 1918, pp. X+166.

[3] Schroeder, E. C. and Cotton, W. E. The bacillus of infectious abortion found in milk. U. S. Dept. Agr. Bur. An. Ind. Rpt. 1911, 139–146. 1913.

[4] Breed, R. S. Cells in milk derived from the udder. N. Y. Agr. Exp. Sta. Bul. 380, 139–200. 1914.

numbers of these leucocytes are highly variable, and in milk of normal type they occasionally occur in such small numbers as to be practically absent. Even in the majority of samples of market milk, the numbers of these leucocytes is not large as compared with the number present in the blood, i. e., less than 500 per cmm. for the majority of milk samples as compared with a normal of 7,500 per cmm. for blood.

Accompanying these leucocytes in milk, there are small numbers of fat-laden epithelial cells (so-called colostral corpuscles) and nuclei, which represent the wastage from the lining epithelial found in the alveoli and ducts of the udder. These bodies, of course, are not found in blood.

All gradations exist between evidently abnormal and strictly normal milk, and conditions that are significant in interpreting the phenomena of milk secretion are found in this intermediate region. Many samples that appear normal to the unaided senses show evidences of slight deviations from normal by chemical or microscopic analysis.

PREVIOUS STUDIES

Probably the first worker to show that milk from infected udders was abnormal in chemical composition and less acid in reaction than normal milk was Storch.[1] Similar results have been obtained by several later investigations, and Rullmann[2] has shown that milk having a high leucocytic count likewise has a low titriable acidity. The latter author sought the explanation of this lowered acidity in the presence of alkali-forming bacteria that more than counteracted the effect of the acid-forming streptococci, but could find nothing to confirm this view.

Fetzer[3] also discusses the changes in milk caused by pathological conditions. He reaches conclusions essentially the same as those of Storch.

Höyberg,[4] working with his rosolic-acid-alcohol test for determining the reaction of milk, concludes that excessive numbers of leucocytes in milk are accompanied by a lessened acidity, which he believes (as does Storch) is caused by the passage of blood serum into milk without change. He finds that whereas a mixture of equal parts of cow's blood serum and normal milk gave a deep red reaction with the rosolic-acid-alcohol reagent, a mixture containing five

---

[1] Storch, V. Analyse der Milch von tuberculösen Kühen. Abstract in Jahresber. d. Thierchem. 14, 170–172. 1885. Also in 19, 157–158. 1889.

[2] Rullmann, W. Über den Enzym- und Streptokokkengehalt aseptisch entnommener Milch. Arch. Hyg. 73, 81–144. 1911.

[3] Fetzer, L. W. Original communication, 8th Internat. Cong. Applied Chem. (Washington and New York) 19, Sect. VIIId, 111–114. 1912. Abstract in Exp. Sta. Rec. 27, 878. 1912.

[4] Höyberg, H. M. Eine Methode zum Nachweis von Kühen deren Milch eine abnorme Menge von Leukozyten samt Fibrinfasern und Bakterien enthält. Zeitschr f. Fleisch- u. Milchhyg. 21, 133–147. 1911.

parts of normal milk to one of blood serum gave a normal reaction for milk. He regards this as indicating that relatively large amounts of unchanged blood serum must pass into milk where the reaction is decidedly less acid than normal.

Höyberg's test is made by adding 5.5 cc. of his rosolic-acid-alcohol reagent to 5 cc. of milk in a test tube. The color obtained is compared with a color chart. The reagent is prepared by adding 4.5 cc. of a 1 per cent alcoholic solution of rosolic acid to 5.0 cc. of 96 per cent alcohol. Tho he gives no warning, care should be taken that the alcohol is acid free.

Bahr[1] has tried Höyberg's test and reports that he has secured fairly satisfactory results with it in detecting cows giving milk with a high leucocyte and bacterial content. He, like Rullmann, sought the explanation of the decreased acidity in the presence of alkali-forming bacteria, but without success. He comes to the conclusion that Höyberg is mistaken in assuming that large quantities of unchanged blood serum are present in the less acid milk, showing that the addition of sufficient blood serum to cause the observed changes in reaction introduces an improbable amount of coagulable proteins. He seeks the explanation of the lessened acidity in the passage of tri-basic sodium phosphate from the blood into the milk without change into mono-basic phosphate.

Turning now to the papers dealing with the relation between the leucocytes and the streptococci, we find practically universal agreement that infections of the udder with pathogenic streptococci are accompanied by the presence of large numbers of leucocytes in the milk. This literature has already been reviewed[2] and need not be again discussed other than to point out that while Russell and Hoffmann[3] found a practically constant relation between these two things, yet they noted several instances where high cell counts occurred without detectable infection with streptococci. In the two cows whose milk was studied during a lactation period by Hastings and Hoffmann,[4] there were consistent high counts of cells accompanied by a streptococcic infection. The latter, however, produced no evident change in the normal appearance of the milk. Likewise, in the work on cell studies previously reported,[5] the history of the fluctuations in cell content of the milk of a cow that had recently freshened was followed for 24 days. In this case, tho the

[1] Bahr, L. Einige Milchuntersuchungen mit besonderer Berücksichtigung des Wertes der Rosolsäurealkoholprobe. Zeitschr. f. Fleisch- u. Milchyg. 24, 228–233, 251–256, 370–376, 398–406, 472–477. 1914.

[2] See footnote 4 on p. 240.

[3] Russell, H. L. and Hoffmann, C. Distribution of cell elements in milk and their relation to sanitary standards. Wis. Agr. Exp. Sta. Rpt. 1907, 231–253.

[4] Hastings, E. G. and Hoffmann, C. Bacterial content of the milk of individual animals. Wis. Agr. Exp. Sta. Research Bul. 6, 189–196. 1909.

[5] See p. 167 of reference given in footnote 4 on p. 240.

milk contained many cells at some milkings, there was no detectable infection with streptococci. The milk was of normal appearance after the colostral period had passed.

Recent work by Cooledge[1] suggests that some of the cases where high cell counts have been obtained in milk of normal appearance are caused by infections with *Bact. abortus*. These organisms are not so readily recognized in milk as are the streptococci, and are now known to occur quite frequently in fresh milk. Purely physiological disturbances in the secretory processes such as occur during the colostral period may also cause fluctuations in cell counts.

TECHNIQUE

In the present work, the reaction of the milk has ordinarily been measured by the use of the brom-cresol-purple test described by Baker and Van Slyke.[2] It was felt that this would be a more delicate indicator of changes of reaction of normal milk than the rosolic-acid indicator used by Höyberg; but in order to test the matter, a comparative trial was made of the two indicators with samples of fresh milk drawn from cows in the Station herd which were selected in such a way that a series of samples was obtained with varying reaction.

For comparison with the two indicators named, three other indicators were used all of which are sensitive to changes where pH values are higher than those of strictly normal milk, but which are not so sensitive where the pH values are those of normal milk (6.50 to 6.60). These were saturated with alcoholic solutions of rosolic-acid, phenol-red, and brom-thymol-blue. In all cases except with Höyberg's reagent, one drop of the indicator was added to 3 cc. of milk. With the latter, the proportion was kept as indicated by the author, namely 5.5 cc. to 5 cc.

At the same time the reaction of the samples was determined electrometrically.

As a result of the color tests on the 11 samples (Table 1), four observers were found to agree on the arrangement of the samples according to differences in shade of color. This sequence in color shades was found to agree with the sequence established electrometrically in all cases where the reaction fell within the known sensitive range of the indicator.

However, the curdling produced by the alcohol in Höyberg's reagent caused irregularities in color in the less sensitive range of rosolic-acid (pH between 6.50 and 6.79). It was only samples

[1] Cooledge, L. H. Studies upon the bacterial flora of samples of milk with high cellular counts as drawn from apparently normal udders. Mich. Agr. Exp. Sta. Tech. Bul. 41, 901–910. 1918.

[2] Baker, J. C. and Van Slyke, L. L. A method for the preliminary detection of abnormal milks. N. Y. Agr. Exp. Sta. Tech. Bul. 71. 1919.

showing greater pH values than this (Samples 8 to 11) that showed a regular sequence in color change. It is interesting to note that all the latter samples were from quarters that were either inflamed at the time or had been affected with garget previously.

TABLE 1.— THE REACTION OF A SERIES OF MILK SAMPLES, RESULTS ARRANGED IN SEQUENCE ACCORDING TO pH VALUES FOR COMPARISON WITH THE COLORS OBTAINED WITH VARIOUS INDICATORS.

SAMPLE NUMBER	pH VALUE *a*	SEQUENCE AS ESTABLISHED BY THE SHADE OF COLOR OF INDICATOR					NOTES
		Brom-cresol-purple *b*	Brom-thymol-blue *c*	Phenol-red *d*	Rosolic-acid *e*	Höyberg's reagent *e*	
1	6.51	1	1	1	1	3	Samples Nos. 1–7 normal in appearance and from apparently normal udders.
2	6.53	2	1	1	1	4	
3	6.54	3	1	1	1	5	
4	6.58	4	1	1	1	2	
5	6.64	5	2	1	1	7	
6	6.73	6	3	2	2	1	
7	6.78	7	4	3	3	6	
8	6.87	8	5	4	4	8	Sample normal, but from a quarter previously affected with garget.
9	6.90	9	6	5	5	9	From inflamed quarter. Normal in appearance.
10	6.95	10	7	6	6	10	Similar to No. 9.
11	7.08	11	8	7	7	11	From quarter badly affected with garget. Abnormal in appearance.

a Determined electrometrically.
b Color change from light blue to dark purple-blue.
c Color change from greenish yellow to green.
d Color change from yellow-orange to red.
e Color change from pink to dark red.

From these results, it was concluded that whereas Höyberg's reagent was sufficiently sensitive to pick out milk that was decidedly less acid than normal, it was not a satisfactory test for the purposes in hand, nor as good for general use as the brom-cresol-purple test.

Differential leucocyte and epithelial cell counts have been made by the method originally described by Prescott and Breed.[1] In making the counts, all of the small cells bearing a close resemblance to mononuclear, polymorphonuclear, and polynuclear leucocytes were included in the one group, while all of the large vacuolated cells of the colostral corpuscle type and all of the large separate nuclei probably originally derived from epithelial cells were counted in a second group. This classification was followed as it is *a priori* improbable that any close relationship exists between the reaction of milk and the amount of epithelial cell debris present.

[1] Prescott, S. C. and Breed, R. S. The determination of the number of cells in milk by a direct method Jour. Inf. Dis. 7, 632–640. 1910.

The presence or absence of streptococci has been determined in each case by a microscopic examination of the stained dried milk as freshly drawn. If this examination was negative, a second microscopic examination was made after incubating the milk sample for 24 hours at 37° C. Streptococci have been reported as present whenever it has been possible to find cocci in chains which consisted of more than four individuals to the chain. Some chains were short, containing scarcely more than the minimum number of organisms; but the majority were long, i.e. contained 20 to 30 or more individuals in the chain.

No conclusions should be drawn concerning the number of samples in any class as the samples were taken from animals known to be infected with streptococci, or giving milk with a reaction less acid than normal in one or more quarters.

The samples were drawn aseptically from individual quarters of the udder and were examined for reaction at once. They were taken after the milking was approximately half completed. The animals in the Station herd are Jerseys, with some grade Jerseys, while the animals in the other herds were Holsteins mixed with common stock.

DATA AND OBSERVATIONS

Observations were made of the reaction, cell, and streptococcic content of 63 samples of milk from cows in the Station herd, and of 61 similar samples from animals in two herds in the neighborhood. These are given in Tables 2, 3, and 4, respectively. In some instances samples were taken from the same animal at different times, in which case several days elapsed between the two examinations.

TABLE 2.— ANALYSES OF MILK FROM DIFFERENT QUARTERS OF THE UDDER OF COWS FROM STATION HERD, SHOWING VARIATION IN REACTION, LEUCOCYTE, AND EPITHELIAL CELL COUNT, AND THE PRESENCE OR ABSENCE OF STREPTOCOCCI.

NUMBER OF COW	QUARTER OF UDDER	REACTION		LEUCOCYTE COUNT PER CC.	EPITHELIAL CELL COUNT PER CC.	STREPTOCOCCI, +PRESENT —ABSENT
		Group	pH			
S 16	R.H.	1	(6.50-6.60)	90,000	30,000	....
	L.H.	4	(6.76-6.84)	1,620,000	210,000	....
	R.F.	4	(6.76-6.84)	4,110,000	270,000	....
S 11	R.F.	4	(6.76-6.84)	240,000	90,000	....
S 23	L.H.	4	(6.76-6.84)	3,690,000	420,000	....
S 6	R.H.	5	(6.84-6.92)	2,460,000	150,000	....
S 12	R.H.[a]	7	(7.00+)	15,900,000	810,000	+
	L.H.[a]	3	(6.68-6.76)	200,000,000	Few	+
	R.F.	2	(6.60-6.68)	1,440,000	240,000	—
	L.F.	5	(6.84-6.92)	5,100,000	360,000	+
S 21	R.H.	1	(6.50-6.60)	60,000	000	—
	L.H.	1	(6.50-6.60)	30,000	60,000	—
	R.F.	1	(6.50-6.60)	000	000	—
	L.F.	1	(6.50-6.60)	000	000	—

[a] Milk from these quarters was abnormal in appearance, all other samples normal in appearance.

TABLE 2.—(*continued*).

Number of cow	Quarter of udder	Reaction: Group	Reaction: pH	Leucocyte count per cc.	Epithelial cell count per cc.	Streptococci, +present —absent
S 21..........	R.H.	1	(6.50–6.60)	000	000	—
	L.H.	1	(6.50–6.60)	120,000	000	—
	R.F.	1	(6.50–6.60)	000	30,000	—
	L.F.	1	(6.50–6.60)	30,000	30,000	—
S 7..........	R.H.	1	(6.50–6.60)	000	60,000	—
	L.H.	1	(6.50–6.60)	30,000	60,000	—
	R.F.	1	(6.50–6.60)	000	30,000	—
	L.F.	1	(6.50–6.60)	30,000	000	—
U 1..........	R.H.	1	(6.50–6.60)	000	10,000	—
	L.H.	1	(6.50–6.60)	000	000	—
	R.F.	2	(6.60–6.68)	20,000	000	—
	L.F.	2	(6.60–6.68)	30,000	000	—
U 2..........	R.H.	1	(6.50–6.60)	110,000	580,000	—
	L.H.	2	(6.60–6.68)	410,000	970,000	—
	R.F.	1	(6.50–6.60)	10,000	180,000	—
	L.F.	1	(6.50–6.60)	40,000	190,000	—
U 3..........	R.H.	7	(7.00+)	21,600,000	1,230,000	+
	L.H.	5	(6.84–6.92)	320,000	200,000	+
	R.F.	1	(6.50–6.60)	40,000	140,000	—
	L.F.	3	(6.68–6.76)	220,000	590,000	+
U 3..........	R.H.	5	(6.85)*b*	20,000,000*c*	?	+
U 4..........	R.H.	2	(6.60–6.68)	20,000	40,000	—
	L.H.	3	(6.68–6.76)	380,000	640,000	+
	R.F.	1	(6.50–6.60)	10,000	70,000	—
	L.F.	1	(6.50–6.60)	30,000	50,000	—
U 5..........	R.H.	1	(6.50–6.60)	000	000	+
	L.H.	2	(6.60–6.68)	000	000	+
	R.F.	2	(6.60–6.68)	000	60,000	—
	L.F.	1	(6.50–6.60)	10,000	60,000	—
U 7..........	R.H.	2	(6.60–6.68)	250,000	270,000	+
	L.H.	7	(7.00+)	34,000,000	1,260,000	+
	R.F.	3	(6.68–6.76)	190,000	370,000	—
	L.F.	2	(6.60–6.68)	60,000	150,000	+
U 8..........	R.H.	1	(6.50–6.60)	70,000	160,000	—
	L.H.	3	(6.60–6.76)	70,000	110,000	+
	R.F.	2	(6.60–6.68)	40,000	120,000	—
	L.F.	2	(6.60–6.68)	110,000	220,000	—
U 9..........	R.H.	1	(6.50–6.60)	110,000	490,000	—
	L.H.	1	(6.50–6.60)	90,000	330,000	—
	R.F.	3	(6.68–6.76)	?	?	—
	L.F.	3	(6.68–6.76)	2,550,000	220,000	+
U 11..........	R.H.	3	(6.68–6.76)	1,510,000	780,000	—
	L.H.	1	(6.50–6.60)	000	000	—
	R.F.	5	(6.84–6.92)	1,520,000	570,000	—
	L.F.	1	(6.50–6.60)	000	000	—
U 12..........	R.H.	2	(6.60–6.68)	160,000	420,000	—
	L.H.	2	(6.60–6.68)	1,030,000	660,000	—
	R.F.	5	(6.84–6.92)	380,000	660,000	—
	L.F.	2	(6.60–6.68)	220,000	490,000	—

b Determined electrometrically.
c Figures are for the total cell count.

TABLE 3.— ANALYSES OF MILK FROM DIFFERENT QUARTERS OF THE UDDER OF COWS FROM C. W. L. HERD, SHOWING VARIATION IN REACTION, LEUCOCYTE AND EPITHELIAL CELL COUNT, AND THE PRESENCE OR ABSENCE OF STREPTOCOCCI.

NUMBER OF COW	QUARTER OF UDDER	REACTION		LEUCOCYTE COUNT PER CC.	EPITHELIAL CELL COUNT PER CC.	STREPTOCOCCI, + PRESENT — ABSENT
		Group	pH			
2	R.H.a	7	(7.00)b	300,000,000	000	+
	L.H.	4	(6.76–6.84)	90,000	60,000	+
	R.F.	4	(6.76–6.84)	300,000	120,000	+
	L.F.	4	(6.76–6.84)	270,000	30,000	—
2	R.H.a	7	(7.06)b	20,000,000	000	+
4	R.H.	2	(6.60–6.68)	000	60,000	—
	L.H.	4	(6.76–6.84)	360,000	480,000	+
	R.F.	2	(6.60–6.68)	60,000	60,000	—
	L.F.	2	(6.60–6.68)	60,000	90,000	—
5	R.H.	4	(6.76–6.84)	2,580,000	300,000	+
	L.H.	5	(6.84–6.92)	8,100,000	570,000	+
	R.F.	7	(7.00+)	40,900,000	000	+
	L.F.	5	(6.84–6.92)	33,800,000	1,800,000	—
6	R.H.	4	(6.76–6.84)	120,000	12,000	+
	L.H.	4	(6.76–6.84)	300,000	30,000	—
	R.F.	4	(6.76–6.84)	1,120,000	120,000	+
	L.F.	4	(6.76–6.84)	900,000	90,000	+
6	R.F.	4	(6.80)b	1,000,000c	?	+
7	R.H.	2	(6.69–6.68)	60,000	90,000	—
	L.H.	3	(6.68–6.76)	000	000	—
	R.F.	2	(6.60–6.68)	000	000	—
	L.F.	2	(6.60–6.68)	180,000	30,000	+
10	R.H.	7	(7.20)b	1,980,000	180,000	+
	L.H.	7	(7.10)b	4,300,000	270,000	+
	R.F.	4	(6.76–6.84)	510,000	60,000	—
	L.F.	4	(6.76–6.84)	800,000	150,000	—
13	R.H.	7	(7.00+)	Innumerable	?	+
	L.H.	1	(6.50–6.60)	120,000	30,000	—
	R.F.	3	(6.68–6.76)	360,000	90,000	—
	L.F.	1	(6.50–6.60)	180,000	90,000	—
14	R.H.	6	(6.92–7.00)	3,900,000	1,200,000	+
	L.H.	7	(7.20)b	4,000,000	330,000	+
	R.F.	7	(7.00)b	7,800,000	300,000	+
	L.F.	6	(6.92–7.00)	1,600,000	420,000	+
14	L.H.	6	(7.00)b	4,000,000c	?	+
	R.F.	6	(6.96)b	10,000,000c	?	+
15	R.H.	2	(6.60–6.68)	360,000	30,000	—
	L.H.	1	(6.50–6.60)	000	000	—
	R.F.	3	(6.68–6.76)	120,000	000	—
	L.F.	4	(6.76–6.84)	810,000	180,000	—
16	?	6	(6.95)b	5,000,000c	?	+
18	?	6	(6.91)b	3,000,000c	?	+

a Milk from this quarter was abnormal in appearance, all other samples normal in appearance.
b Determined electormetrically.
c Figures are for the total cell count.

TABLE 4.— ANALYSES OF MILK FROM DIFFERENT QUARTERS OF THE UDDER OF COWS FROM G. F. F. HERD SHOWING VARIATIONS IN REACTION, LEUCOCYTE AND EPITHELIAL CELL COUNT, AND THE PRESENCE OR ABSENCE OF STREPTOCOCCI.

NUMBER OF COW	QUARTER OF UDDER	REACTION		LEUCOCYTE COUNT PER CC.	EPITHELIAL CELL COUNT PER CC.	STREPTOCOCCI, + PRESENT — ABSENT
		Group	pH			
5	R.H.	1	(6.50–6.60)	30,000	60,000	—
	L.H.	5	(6.84–6.92)	540,000	3,300,000	+
	R.F.*d*	5	(6.84–6.92)	16,500,000	840,000	—?
	L.F.	1	(6.50–6.60)	30,000*c*	000	—
5	R.F.*d*	6	(7.04)*b*	3,000,000*c*	?	+
10	R.H.	6	(6.92–7.00)	3,180,000	660,000	+
	L.H.*a*	3	(6.68–6.76)	740,000	240,000	+
	R.F.	6	(6.92–7.00)	1,740,000	210,000	—
	L.F.	5	(6.84–6.92)	1,770,000	390,000	+
11	R.H.	7	(7.00+)	15,300,000	930,000	+
	L.H.	1	(6.50–6.60)	120,000	000	—
	R.F.	3	(6.68–6.76)	1,020,000	570,000	+
	L.F.	1	(6.50–6.60)	330,000	60,000	—
11	R.H.	7	(7.15)*b*	21,000,000*c*	?	+
19	R.H.	3	(6.68–6.76)	2,040,000	240,000	+
	L.H.	6	(6.92–7.00)	7,380,000	450,000	+
	R.F.	1	(6.50–6.60)	000	000	—
	L.F.	1	(6.50–6.60)	000	000	—
19	L.H.	6	(6.98)*b*	8,400,000*c*	?	+

a Milk from this quarter was abnormal in appearance, all other samples normal in appearance.
b Determined electrometrically.
c Figures are for the total cell count.
d No streptococci were found in the milk of this quarter on the first trial; but as they were present a few days later, it is evident that this was an oversight.

As it is difficult to pick out the relationships existing between the reaction, cell content, and streptococci from the results as obtained, they have been arranged in Tables 5, 6, and 7 in such a way as to contrast the reaction with the leucocyte content, the epithelium cell content, and the presence of streptococci. Finally, the averages of these tables have been combined in Table 8 for convenience in comparison.

Even a casual examination of the results in Tables 2, 3, and 4 shows that a relationship exists between the number of leucocytes present and the reaction of the milk. This appears in a more striking way in Table 5 in which the results are arranged according to a scale of decreasing acidity. From this it appears that the highest leucocyte count noted from milk with the reaction of Group 1 (pH values between 6.50 and 6.60) was 330,000 per cc., while the average count for the 37 samples in this class was only 46,000.

Fourteen of these samples contained so few leucocytes that none were observed in the microscopic examination of one three-thousandth part of a cubic centimeter.

TABLE 5.—COMPARISON BETWEEN THE REACTION AND THE LEUCOCYTE CONTENT OF MILK OF NORMAL APPEARANCE.

Leucocyte counts given in thousands per cc.

Group 1, pH 6.50–6.60		Group 2, pH 6.60–6.68	Group 3, pH 6.68–6.76	Group 4, pH 6.76–6.84	Group 5, pH 6.84–6.92	Group 6, pH 6.92–7.00	Group 7, pH 7.00 +
90	60	1,440	220	1,620	2,460	3,900	21,600
30	0	0	380	4,110	5,100	1,600	34,000
0	0	30	190	240	320	4,000	40,900
120	0	410	70	3,690	20,000	10,000	1,980
30	0	20	2,550	90	1,520	3,000	4,300
30	0	0	1,510	300	380	3,180	Innumerable
30	0	0	0	270	8,100	1,740	4,000
120	110	250	360	360	33,800	7,380	7,800
10	40	60	120	2,580	540	8,400	15,300
40	10	40	1,020	120	16,500	3,000	21,000
30	0	110	2,040	300	1,770	5,000	....
10	70	160	....	1,120	....	....	....
110	90	1,030	....	900	....	....	....
0	0	220	....	510	....	....	....
180	0	0	....	800	....	....	....
30	30	60	....	810	....	....	....
330		60	....	1,000	....	....	....
0		60	....	....	....	....	....
120		20	....	....	....	....	....
0		180	....	....	....	....	....
0		360	....	....	....	....	....
Ave......46		215	770	1,110	8,230 5,670a 4,080b	4,650	16,800

a One excessive count omitted from the average.
b Two excessive counts omitted from the average.

In the 21 samples in which there was a slight but perceptible darkening of the brom-cresol-purple (pH values between 6.60 and 6.68), it will be noted that whereas 4 samples contained so few leucocytes that none were seen in the microscopic examination, 2 samples contained in excess of 1,000,000 per cc. (maximum 1,440,000). The average leucocyte content of the 21 samples was 215,000 per cc.

With certain exceptions to be noted presently, there is a gradual, tho somewhat irregular, increase in the number of leucocytes with decreasing acidity as shown by the regular increase in the average

leucocyte count for each group of samples. This reaches its climax in the 10 samples of milk in which the pH values are greater than 7.00. In these the lowest leucocyte count was 1,980,000, and the highest 40,900,000 per cc. The average count for this group was 16,800,000 per cc.

TABLE 6.—COMPARISON BETWEEN THE REACTION AND THE EPITHELIAL CELL CONTENT OF MILK OF NORMAL APPEARANCE.

Epithelial cell counts given in thousands per cc.

Group 1, pH 6.50–6.60		Group 2, pH 6.60–6.68	Group 3, pH 6.68–6.76	Group 4, pH 6.76–6.84	Group 5, pH 6.84–6.92	Group 6, pH 6.92–7.00	Group 7, pH 7.00+
30	0	240	590	210	150	1,200	1,230
60	0	0	640	270	360	420	1,260
0	0	0	370	90	200	660	0
0	30	970	110	420	570	210	180
30	60	40	220	60	660	450	270
60	30	0	780	120	570	....	330
0	10	60	0	30	1,870	....	300
0	580	270	90	480	3,300	....	930
180	190	150	0	300	840	....	....
140	70	120	570	12	390	....	....
50	0	220	240	30	....	....	....
60	160	420	....	120	....	....	....
490	330	660	....	90	....	....	....
0	0	490	....	60	....	....	....
30	90	60	....	150	....	....	....
0	60	60	....	180	....	....	....
0		90	....	....	....	....	....
60		90	....	....	....	....	....
0		0	....	....	....	....	....
0		30	....	....	....	....	....
0		30	....	....	....	....	....
Ave......	75	190	330	160	890	590	560

Two counts were so widely divergent from the usual conditions that they were not included in the averages. The two unusual samples (Table 2, Cow U 3, L.F., and Table 3, Cow 5, L.F.) fell in Group 5 (pH values 6.84 to 6.92). One gave a leucocyte count of 20,000,000 and the other of 33,800,000 per cc. These counts are both greatly in excess of the average count for samples in this group. In the first of these cases, a sample taken from the same quarter a few days previously had given an almost identical count (21,600,000 per cc.) with a less acid reaction (pH 7.00+).

In spite of these and other less noticeable exceptions, the observations are in general accord with the theory that decreased acidity

is correlated with an increase in the number of leucocytes present in fresh milk. Minor irregularities are explainable by inaccuracies of technique, while some of the larger ones are undoubtedly due to the influence on the reaction of the production of acid from lactose by streptococci. No satisfactory explanation of these relationships is evident if the leucocytic nature of the cells is denied as is done by Winkler[1] and also by Hewlett, Villar, and Revis.[2]

TABLE 7.—COMPARISON BETWEEN THE REACTION AND THE PRESENCE (+) OR ABSENCE (—) OF STREPTOCOCCI IN MILK OF NORMAL APPEARANCE.

GROUP 1, pH 6.50–6.60		GROUP 2, pH 6.60–6.68	GROUP 3, pH 6.68–6.76	GROUP 4, pH 6.76–6.84	GROUP 5, pH 6.84–6.92	GROUP 6, pH 6.92–7.00	GROUP 7, pH 7.00+
—	—	—	+	+	+	+	+
—	—	—	+	+	+	+	+
—	—	—	+	—	+	+	+
—	—	—	—	+	—	+	+
—	—	—	+	+	—	+	+
—	—	—	—	+	—	+	+
—	—	+	—	+	+	+	+
—	—	+	—	+	+	+	+
—	—	+	—	+	—?	—	+
—	—	—	—	—	+	+	+
—	+	—	+	—	....	+	....
—	—	—	+	—	....	....	....
—	—	—	+	—	....	....	....
—	—	—	....	....	....	....	....
—	—	—	....	....	....	....	....
—		—	....	....	....	....	....
—		—	....	....	....	....	....
—		+	....	....	....	....	....
—		—	....	....	....	....	....
—		—	....	....	....	....	....
—		—	....	....	....	....	....
Per cent + = 3		19	54	62	60	91	100

The relation between the amount of cellular debris of epithelial origin and the reaction as shown in Table 6 does not appear to be as striking as that with the leucocytes. Where the results are arranged according to reaction and the cell counts averaged, it is evident that there is more epithelial cell debris in the samples with

[1] Winkler, W. Die Milchbildung und Mikroskopische Milchprüfung. Zeitschr. f. Landwirtsch. Versuchswes. Oesterreich. 11, 562–630. 1908.

[2] Hewlett, R. T., Villar, S., and Revis, C. On the nature of the cellular elements present in milk. Jour. Hyg. 9, 271–278. 1909; 10, 56–92. 1910; 11, 97–104. 1911; 13, 87–92. 1913.

the lowest acidity. Yet the increase in amount of cell debris with decreasing acidity is not regular. This suggests that the relationship between the two things is not a close one, and agrees with the conception that inflamed conditions are likely to cause a discharge of an increased but irregular amount of epithelial cell debris.

TABLE 8.— COMPARISON BETWEEN THE COMBINED AVERAGES OF TABLES 5, 6, AND 7.

	GROUP 1, pH 6.50–6.60	GROUP 2, pH 6.60–6.68	GROUP 3, pH 6.68–6.76	GROUP 4, pH 6.76–6.84	GROUP 5, pH 6.84–6.92	GROUP 6, pH 6.92–7.00	GROUP 7, pH 7.00+
Ave. leucocyte count (thousands per cc.)..	46	215	770	1,110	4,080a	4,650	16,800
Ave. epithelial cell count (thousands per cc.)	75	190	330	160	890	590	560
Percentage of samples containing streptococci	3	19	54	62	60	91	100

a Two excessive counts omitted from the average.

In considering the possible relationship between the reaction and the presence or absence of streptococci, the conditions under which such a condition might exist should be kept in mind. The pathogenic streptococci are well known incitors of inflammatory processes in animal tissues, and are common causes of such troubles in udders. During any disturbance of this type in the udder, the leucocytes tend to congregate in large numbers. Both the leucocytes and an accompanying serous exudate probably pass thru the glandular epithelium under these conditions. At first there would be little, if any, actual disorganization of the glandular epithelium but eventually, as shown in the excellent figures drawn by Ernst,[1] the lining of certain alveoli in limited areas would actually break down, thus allowing the direct entrance of lymph, or even blood serum, by the rupture of the walls of the vessels carrying these body fluids. In the later stages, this disorganization would involve large areas, even entire quarters of the udder. The secretion would no longer have the appearance of normal milk under such conditions.

During the period previous to the actual rupture of the epithelium and vessels, it seems probable that the normal life processes controlling the entrance and elaboration of the blood nutrients in the gland cells would be weakened or modified. A natural change would be for the readily dialyzable substances of the blood, such as the mineral salts, urea, glucose and amino acids, to pass into the

[1] Ernst, W. Grundriss der Milchhygiene für Tierärzte. Stuttgart: 1913, pp. VIII + 301.

milk with the serous exudate without undergoing the usual processes of elaboration. However, the chemical findings previously reported[1] indicate that even under these conditions the glucose is transformed into lactose. (See also Porcher.[2]) If, however, the mineral salts of the blood (especially sodium bicarbonate and basic phosphates) pass into the milk they would reduce the hydrogen ion concentration, even tho the remaining substances of the blood serum did not enter.

The entrance of some other substances in unaltered condition early in this process is indicated by the fact that fibrin is readily demonstrated by appropriate stains in the less acid milk. This would indicate that, under the intermediate conditions before there is actual entrance of unaltered serum, there is a considerable period during which there is an entrance of modified or partially elaborated serum.

Another factor having a direct influence on the hydrogen ion concentration which ought not to be overlooked is the formation of acid by the streptococci by the fermentation of glucose or lactose. From the fact that the reaction of the streptococcus infected milk is less acid than normal, it is evident that there must be a surplus of the substances causing a reduction in hydrogen ion concentration. So long as the new materials are being secreted the acidity is ordinarily neutralized, but as soon as the milk is drawn the streptococcic fermentation quickly changes the reaction to an acid one. This was evident in several samples where flocculent masses of bacteria settled to the bottom of sample tubes to which brom-cresol-purple had been added. Within 30 minutes acid areas showed about each of the flocculent masses.

Even a casual study of the data given in Tables 2, 3, and 4 will show that streptococci were usually present in those cases where there were excessive numbers of cells accompanied by decreased acidity. The correlation between decreased acidity and the presence of streptococci is, however, shown more clearly in Table 7. In this summary it will be seen that whereas only one sample out of 36 (3 per cent) with a normal reaction (pH values from 6.50 to 6.60) was found to contain streptococci, the percentage of streptococcic infection increased regularly with decreasing acidity. This reached its climax in Group 7 (pH values 7.00+) all of which contained streptococci.

Certain exceptional conditions are worth a further word of explanation. The single sample of milk with normal reaction (Table 2, Cow U 5, R.H.) that contained streptococci contained so few of them

---

[1] See footnote 1 on p. 240.

[2] Porcher, Ch. Sur l'origine du lactose. De l'ablation des mamelles chez les femelles en lactation. Compt. Rend. Acad. Sci. Paris 141, 73–75. 1905. Sur l'origine du lactose. Des effets des injections de glucose chez les femelles en lactation. Compt. Rend. Acad. Sci. Paris 141, 467–469. 1905.

that they did not appear in a microscopic examination of the milk until after incubation for 24 hours at 37° C. The cell count was likewise zero for one three-thousandth part of a cc. Evidently the infection in this case was dormant or so localized that it did not affect the reaction.

The single sample in Group 6 (pH values 6.92 to 7.00) that showed no streptococcic infection (Table 4, Cow 10, R.F.) was taken from an udder where all of the other quarters were infected with streptococci and one of them giving abnormal gargety milk. The leucocyte count was high (1,740,000 per cc.) and the conditions indicate that the inflammation in the other quarters had influenced the secretion in the uninfected quarter.

In one of the samples of Group 5 (pH values 6.84 to 6.92) reported as negative for streptococci, a question mark has been added because a sample taken from the same quarter a few days later contained streptococci. The other negatives in this group may likewise have been caused by failure to find the streptococci, or they may have been caused by infection with other pathogenic organisms. Some were from cows where streptococcic infections were present in other quarters, while some were from cows where no streptococcic infection could be detected with the technique used.

When the combined averages are compared as in Table 8, it is seen that the conditions governing the reaction, presence of leucocytes, epithelial debris, and streptococci are all in harmony with the idea that decreased acidity is primarily caused by the entrance of the alkaline substances contained in the lymph and blood serum. It is not probable that entirely unaltered blood serum enters until the inflammatory processes have gone so far that there is actual rupture of the blood vessels. Accompanying the entrance of these alkaline substances there is a fairly regular increase in the entrance of leucocytes, and a less regular increase in the amount of epithelial debris. In a majority of the samples examined, the primary cause of these changes appeared to be an infection with streptococci.

CONCLUSIONS

In the previous bulletin already mentioned,[1] it is suggested that decreased acidity of fresh milk is due to the direct filtration of blood serum into the milk as secreted. In support of this opinion it is pointed out: (1) That this view is in harmony with the changes in composition that accompany decreased acidity; (2) that it is in agreement with the hydrogen ion concentration of normal milk (pH values 6.50 to 6.60) and that of blood serum (pH about 7.60); and (3) that it harmonizes with an increased CO_2 content of the less acid milk, normal milk containing about 10 per cent by volume of CO_2 and blood serum 65 per cent.

[1] See footnote 1 on p. 240.

Further proof of the presence of blood serum was furnished by the evidence that fibrin was present as shown by fibrin stains. This constituent of blood does not appear in normal milk.

The only observed chemical relationship that was out of harmony with the view that unchanged blood serum caused the low acidity of certain samples of milk was the fact that no glucose could be demonstrated in several samples in which it should have been present in appreciable quantities if this were the case. At that time it was suggested that further investigations were desirable.

From the new data here given, and from histological and physiological considerations, it appears that a more exact statement of the case would be that the infection causes the entrance of a serous exudate derived by the gland cells directly from the lymph rather than from the blood. This serous exudate is neither exactly like blood serum nor milk. When the infection has proceeded to the place that actual rupture of the vessels occurs then unchanged lymph and blood would enter. The modifications in the secretions may be due to a weakening of the secretory activity of the cells or the exudate may have a definite protective function against the bacterial infection, or both conditions may hold simultaneously.

The processes involved are so complicated that it is little wonder that the matter is not clear even with the data at hand. It seems quite probable however that the increased CO_2 content of the milk samples having a lowered acidity is correlated with the entrance of alkaline bicarbonates from the blood. The acidity of the milk would also be lessened by the entrance of increased amounts of basic phosphates or even of albumins. Changes in the secretion of the milk in relation to these substances could easily explain the changes in reaction actually noted without assuming the entrance of excessive amounts of unchanged blood serum or lymph. While these chemical changes are still only partially understood, the data establish the fact that the modifications of the secretion are correlated with an increased entrance of the leucocytes into the lumina of the alveoli. Accompanying this change in the secretory processes there also is an increasing amount of wastage from the glandular epithelium.

ACKNOWLEDGMENTS

In this work, involving, as it does, an intimate knowledge of the chemical composition of milk, the authors have called upon their colleague, Dr. L. L. Van Slyke, freely for suggestion and advice. Likewise we are under obligation to Mr. James Madigan (Sanitary Inspector) and to Miss Mildred Davis (Bacteriologist) of the City of Geneva for aid in securing especially instructive samples; and to Miss Davis and Mr. J. W. Bright (formerly of the Station Staff) for having made the microscopic preparations and cell counts. Our thanks are given all of these for this help.

REPORT

OF THE

Department of Biochemistry

R. J. ANDERSON, *Chief in Research (Biochemistry).*

W. L. KULP, *Assistant in Research (Biochemistry).*

TABLE OF CONTENTS

REPORT OF THE DEPARTMENT OF BIOCHEMISTRY

CONCERNING INOSITE PHOSPHORIC ACIDS *

R. J. ANDERSON

SUMMARY

In the first part of the bulletin are recorded the results which have been obtained in efforts to synthesize phytic acid.

A study has been made of the reaction between inosite, phosphoric acid, and phosphorus pentoxide.

The conclusion of Posternak that the organic phosphoric acid produced in this reaction is identical with the natural phytic acid or inosite hexaphosphoric acid, $C_6H_{18}O_{24}P_6$, or as formulated by Posternak, $C_6H_{24}O_{27}P_6$, could not be confirmed.

The only product which could be isolated in approximate purity from the reaction mixture corresponded to an inosite ester of pyrophosphoric acid containing four atoms of phosphorus or two molecules of pyrophosphoric acid. Traces of other inosite phosphoric acids are undoubtedly formed but the above substance represents the principal product of the reaction.

This new acid corresponds to the formula, $C_6H_{12}O_{16}P_4$. It resembles phytic acid in that it contains very nearly the same percentage of phosphorus but its properties and reactions differ in several important particulars from those of phytic acid.

The synthesis of phytic acid or inosite hexaphosphoric acid cannot be considered as accomplished and it appears doubtful if this substance can be successfully synthesized by the methods heretofore employed.

The second part of the bulletin contains an account of further investigations regarding the composition of the inosite phosphoric acid of wheat bran.

Data obtained from the analyses of carefully purified and recrystallized barium salts of the organic phosphorus compound of wheat bran are in close agreement with the calculated composition of barium salts of inosite hexaphosphoric acid.

Silver salts were prepared from the acid and these were found to agree with the formula $C_6H_6O_{24}P_6Ag_{12}$.

The composition of phytic acid of plants as determined from the analyses of salts of this acid corresponds to inosite hexaphosphoric acid, $C_6H_{18}O_{24}P_6$ or $C_6H_6O_6[PO(OH)_2]_6$.

* Reprint of Technical Bulletin No. 79, May, 1920.

I. SYNTHESIS OF PHYTIC ACID

INTRODUCTION

Several attempts to synthesize phytic acid or inosite hexaphosphoric acid have been described in recent years. The methods have varied slightly but the principle in every experiment has been to obtain the desired product by heating together inosite and orthophosphoric acid.

Contardi (1909)[1] claimed to have synthesized phytic acid in this way and described his product as identical with the natural phytic acid isolated from plant material. Carré (1911) was unable to substantiate the results of Contardi. Jegorow (1914) using a similar method obtained a substance containing organic phosphorus. The writer (1912a) showed several years ago that inosite tetraphosphoric acid could be formed by heating inosite and phosphoric acid to 140–160° C. under reduced pressure.

Posternak (1919c) claimed recently to have synthesized phytic acid by heating a mixture of inosite, phosphoric acid, and phosphorus pentoxide. He states that the synthetic phytic acid was isolated as a crystalline double calcium-sodium salt which after drying at 120° had the composition $C_6H_{12}O_{27}P_6Ca_2Na_6$. The analytical data are not given, but a comparative study of the crystallography of the natural and the synthetic salts is described. Posternak calls this acid "inosite hexaphosphoric acid" but he represents it by the formula $C_6H_{24}O_{27}P_6$. This formula differs from that of inosite hexaphosphoric acid, $C_6H_{18}O_{24}P_6$, by containing three molecules more of H_2O. How or in what manner these extra molecules of water are combined is not stated.

As a result of his earlier experiments to synthesize phytic acid by heating inosite and phosphoric acid, which only resulted in the formation of inosite tetraphosphoric acid; and in view of the fact that phytic acid always decomposes when heated into mixtures of inorganic phosphoric acid and lower inosite phosphoric acids, the writer was led to express the opinion (1919) that phytic acid could never be synthesized by heating together inosite and phosphoric acid.

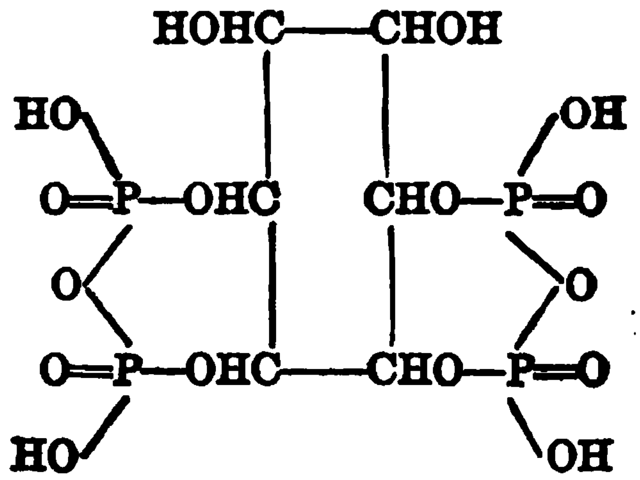
Since the method adopted by Posternak differed from those discussed above only by the introduction of phosphorus pentoxide, it appeared of interest to repeat his work. Accordingly the reaction between inosite and a mixture of phosphoric acid and phosphorus pentoxide has been studied. The conditions of the reaction as described by Posternak were followed closely.

From the reaction mixture was isolated an inosite phosphoric acid which was not identical in composition with the natural phytic acid altho it had very nearly the same percentage of phosphorus.

[1] Reference to Literature Cited, p. 275.

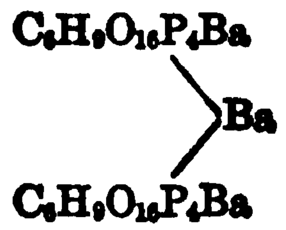
The substance differed not only in composition from phytic acid, but its properties and reactions with reagents also differed from those of phytic acid in several particulars.

The composition of this new inosite phosphoric acid, as determined by the analyses of the barium and the silver salt, and of the free acid itself, agrees with the formula $C_6H_{12}O_{16}P_4$. This corresponds to inosite dipyrophosphoric acid in which two hydroxyls of each molecule of the pyrophosphoric acid have reacted with two alcoholic hydroxyls of the inosite as indicated in the formula:



It is not possible to state, however, whether the constitution of the acid is accurately indicated by this formula, for the inosite may possibly be combined with a more condensed phosphoric acid.

The barium salt of this new acid corresponds to the formula $C_{12}H_{18}O_{32}P_8Ba_5$. Such a substance is either a mixture of the mono- and dibarium salts or else two molecules of the monobarium salt are united by one atom of barium:



The silver salt is precipitated from a slightly acid solution, on addition of silver nitrate, as a white amorphous precipitate which corresponds to the tetrasilver salt, $C_6H_8O_{16}P_4Ag_4$.

EXPERIMENTAL

First Synthesis

Dry orthophosphoric acid, 56 grams, was heated in a flask to 100°, and 12 grams of dry inosite were added. The inosite was dissolved by continuing the heat between 100–110°. To this solution were added 90 grams of phosphorus pentoxide in small portions. A very considerable increase in the temperature was observed when the phosphorus pentoxide was added. The mixture was well stirred by shaking and, finally, by a glass spatula. The flask containing

the reaction mixture was then heated in an oil bath to 120–130° for three hours. It was cooled to room temperature, about 200 cc. of water were added, and the mixture of acids was dissolved by adding a 20 per cent solution of sodium hydroxide until the reaction was faintly alkaline to litmus. The solution was then filtered and concentrated on the water bath and set aside to allow sodium phosphate, pyrophosphate, etc., to crystallize.

The crystals were filtered off on a Buchner funnel and washed with several small portions of cold water. The filtrate was made up to 500 cc. with water, 25 grams of sulfuric acid were added, and the solution was heated to 100° for one hour, for the purpose of converting any pyrophosphoric acid into orthophosphoric acid. It has been shown by Plimmer (1913) that phytin is not appreciably hydrolyzed by such treatment. Sodium hydroxide was then added until the reaction was only faintly acid.

The organic and the inorganic phosphoric acids which were present in the solution were then precipitated by adding a concentrated solution of copper acetate in excess. The copper precipitate was filtered on a Buchner funnel and washed until free from sulfates; then it was suspended in water and decomposed with hydrogen sulfide. The copper sulfide was filtered off and the excess of hydrogen sulfide removed by a current of air. To the filtrate, about 5 liters, were added 400 grams of barium chloride, resulting in a heavy white amorphous or granular precipitate. This precipitate was filtered and washed with water until free from chlorides. The addition of an equal volume of alcohol to the filtrate produced a voluminous white precipitate which was purified as will be described later.

Purification of the Substance Precipitated by Barium Chloride

The moist precipitate was rubbed up to a thin paste with water and brought into solution by adding dilute hydrochloric acid drop by drop. It was then filtered and precipitated by adding a solution of barium hydroxide. The barium salt was filtered and washed free of chlorides with water and again dissolved in dilute hydrochloric acid, filtered, and precipitated by adding an equal volume of 95 per cent alcohol. The above mentioned alternate precipitations with barium hydroxide and alcohol from dilute hydrochloric acid were repeated four times. The substance was further precipitated twice with alcohol from dilute hydrochloric acid, finally washed with dilute alcohol and alcohol and ether, and dried in vacuum over sulfuric acid. It was a snow-white amorphous powder and weighed 7.3 grams.

Various attempts were made to crystallize this barium salt by the method formerly used in purifying barium phytate (1914a), but without success. The amorphous salt was free from chlorides and

inorganic phosphate and it did not contain any weighable quantity of sodium. When dissolved in dilute nitric acid it gave a pure white flocculent precipitate with ammonium molybdate. In strong solutions this precipitate appears immediately while in very dilute solutions it comes down only on warming. The precipitate remains pure white in color and does not turn yellow on warming to 65° or on standing at room temperature for a long time. Before the inorganic phosphate had been removed by the repeated precipitation of the barium salt by alcohol from dilute hydrochloric acid, the white precipitate produced by the ammonium molybdate assumed a yellow color either immediately or very gradually, depending upon the amount of inorganic phosphate which was present.

The substance was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.2980 gm. substance gave 0.0427 gm. H_2O and 0.1121 gm. CO_2.
0.1577 " " " 0.0861 gm. $BaSO_4$ and 0.1018 gm. $Mg_2P_2O_7$.
Found: C = 10.26; H = 1.60; P = 17.99; Ba = 32.12 per cent.
For $C_{12}H_{18}O_{32}P_8Ba_3$ = 1,334, calculated: C = 10.79; H = 1.34; P = 18.59; Ba = 30.88 per cent.

Deducting the amount of barium found and allowing for its equivalent as hydrogen and water the composition of the free acid was calculated as follows:

C = 15.01; H = 3.03; P = 26.34 per cent.
For $C_6H_{12}O_{16}P_4$ = 464, calculated: C = 15.51; H = 2.58; P = 26.72 per cent.

Examination of the Substance Precipitated by Alcohol

The white amorphous precipitate obtained by the addition of alcohol to the filtrate from the above barium salt was purified by precipitating it alternately fifteen times with barium hydroxide and alcohol from dilute hydrochloric acid in the manner described above. The snow-white amorphous product finally obtained gave in nitric acid solution a voluminous white precipitate with ammonium molybdate which gradually turned yellow on warming, thus showing the presence of inorganic phosphate. The substance was then dissolved in 200 cc. of very dilute hydrochloric acid and precipitated by adding 200 cc. of a saturated solution of barium chloride. The heavy white precipitate which separated was filtered, washed, and again precipitated several times from dilute hydrochloric acid by alcohol. After finally filtering, the substance was washed free from chlorides with dilute alcohol and then washed in alcohol and ether and dried in vacuum over sulfuric acid. The snow-white product weighed 4 grams. Dissolved in dilute nitric acid it gave a voluminous pure white precipitate with ammonium molybdate which did not turn yellow on heating. The inorganic phosphate had, therefore, been removed completely.

The substance was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.3343 gm. substance gave 0.0399 gm. H_2O and 0.1031 gm. CO_2.
0.1768 " " " 0.1058 gm. $BaSO_4$ and 0.1135 gm. $Mg_2P_2O_7$.
Found: C = 8.41; H = 1.33; P = 17.89; Ba = 35.21 per cent.
Calculated to free acid: C = 12.88; H = 2.83; P = 27.41 per cent.

The composition differs considerably from that of the first preparation obtained by precipitating with barium chloride, the precentage of carbon being lower and that of phosphorus higher. The composition approaches that of phytin or inosite hexaphosphoric acid, but its properties differ from those of phytin in that it is precipitated from dilute hydrochloric acid solutions by barium chloride and, also, in that its solution in dilute nitric acid gives a white amorphous precipitate with ammonium molybdate. Further, it was not possible to obtain any crystalline barium salts by the method used with barium phytates. Another difference in behavior was noticed in that the addition of water to the dilute hydrochloric acid solution of the barium salt gave a white precipitate.

This substance was probably a mixture of inosite phosphoric acids, but the nature of these esters could not be determined.

Second Synthesis

Since in the first experiment no evidence had been obtained of the formation of phytic acid or inosite hexaphosphoric acid, it was decided to study the reaction between inosite, orthophosphoric acid, and phosphorus pentoxide under conditions varying from that described above. A second synthesis was therefore carried out as follows:

Inosite, 9 grams, dry phosphoric acid, 39 grams, and phosphorus pentoxide, 39 grams, were mixed and heated in a flask exactly as described before except that the temperature of the oil bath did not exceed 120° and the mixture was heated for only one hour. The reaction mixture was worked up exactly as previously described and the substance precipitated by barium chloride was purified in the same manner as the first preparation by precipitating alternately with barium hydroxide and alcohol from dilute hydrochloric acid until the dilute nitric acid solution gave a pure white precipitate with ammonium molybdate. The product thus prepared was a snow-white powder which weighed 6.8 grams after drying in vacuum over sulfuric acid. It was free from chlorides and inorganic phosphate and did not contain any bases other than barium.

The substance was analyzed after drying at 110° in vacuum over phosphorus pentoxide.

0.3993 gm. substance gave 0.0558 gm. H_2O and 0.1548 gm. CO_2.
0.1835 " " " 0.0938 gm. $BaSO_4$ and 0.1220 gm. $Mg_2P_2O_7$.
Found: C = 10.57; H = 1.56; P = 18.53; Ba = 30.08 per cent.
Calculated to free acid: C = 15.03; H = 2.83; P = 26.34 per cent.

Judging by the analytical result this product is evidently identical with the one obtained in the first synthesis.

Third Synthesis

In a third experiment 9 grams of inosite, 39 grams of dry phosphoric acid, and 39 grams of phosphorus pentoxide were heated for one hour in an oil bath having a temperature of 115–120°. The reaction product was isolated in the same manner as before. The substance after drying in vacuum over sulfuric acid weighed 11.7 grams. It was free from chlorides and inorganic phosphate, and bases other than barium were absent.

For analysis the substance was dried in vacuum at 105° over phosphorus pentoxide.

0.3543 gm. substance gave 0.0535 gm. H_2O and 0.1419 gm. CO_2.
0.1891 " " " 0.0913 gm. $BaSO_4$ and 0.1270 gm. $Mg_2P_2O_7$.
Found: C = 10.92; H = 1.68; P = 18.72; Ba = 28.41 per cent.
Calculated to free acid: C = 15.17; H = 2.90; P = 25.99 per cent.

The percentage of barium varied in these different preparations, yet when the barium is deducted, allowing for corresponding quantities of hydrogen and water, fairly concordant results are obtained for the composition of the acid. These analytical results as shown below agree with an acid having the composition $C_6H_{12}O_{16}P_4$.

For $C_6H_{12}O_{16}P_4$ calculated... C = 15.51; H = 2.58; P = 26.72 per cent.
Found first synthesis....... C = 15.01; H = 3.03; P = 26.34 " "
Found second synthesis..... C = 15.03; H = 2.83; P = 26.34 " "
Found third synthesis...... C = 15.17; H = 2.90; P = 25.99 " "

Purification of the Barium Salt

In the hope of obtaining a homogeneous crystalline salt of this acid the following experiment was made. The three barium precipitates of identical composition obtained by precipitating with barium chloride were united. The mixture weighed 22.8 grams. It was rubbed up to a fine thin paste with 200 cc. of water and brought into solution by adding just sufficient dilute hydrochloric acid. The solution was filtered and to it was added slowly and with constant shaking a concentrated solution of 11 grams of barium chloride. The precipitate which formed at first dissolved on shaking and warming the mixture to about 65°. After adding all the barium chloride a slight permanent cloudiness remained which did not clear up on warming. The solution was then allowed to cool and to stand at room temperature over night. A heavy white powder separated gradually. This substance was not crystalline but it consisted, as shown under the microscope, of uniform transparent granules or globular particles.

This substance was filtered off, washed with water and then with alcohol and ether, and allowed to dry in the air. The snow-white powder weighed 3.1 grams. In nitric acid solution it gave no reaction with silver nitrate, and ammonium molybdate produced a voluminous pure white precipitate indicating that it was free from chlorides and inorganic phosphate. To the filtrate from this preparation was added a concentrated solution of 20 grams of barium chloride in the same manner as before until a faint permanent cloudiness remained. After standing over night a further quantity of the globular precipitate had separated which, under the microscope, appeared to be identical with the first preparation. This was filtered off, washed and dried as before, and was also found to be free from chlorides and inorganic phosphate.

These preparations were analyzed after drying to constant weight at 105° in vacuum over phosphorus pentoxide.

The first globular preparation gave the following results on analysis:

0.3784 gm. substance lost 0.0536 gm. on drying.
0.1813 " " " 0.0257 gm. on drying.
0.3248 " " gave 0.0463 gm. H_2O and 0.1267 gm. CO_2.
0.1476 " " " 0.0757 gm. $BaSO_4$ and 0.0986 gm. $Mg_2P_2O_7$.
Found: C = 10.63; H = 1.59; P = 18.62; Ba = 30.18; H_2O = 14.16 per cent.
For $C_{12}H_{18}O_{32}P_8Ba_3$ = 1,334, calculated: C = 10.79; H = 1.34; P = 18.59; Ba = 30.88 per cent.
For 12 H_2O, calculated: 13.93 per cent.

The second preparation gave the following results:

0.2834 gm. substance gave 0.0382 gm. H_2O and 0.1050 gm. CO_2.
0.1887 " " " 0.1062 gm. $BaSO_4$ and 0.1224 gm. $Mg_2P_2O_7$.
On drying it lost 14.61 and 14.51 per cent of water.
Found: C = 10.10; H = 1.50; P = 18.08; Ba = 33.12 per cent.

In these preparations the percentage of barium again varies, but on deducting the amount of barium found and allowing for a corresponding quantity of hydrogen and water the following results are obtained:

First globular precipitate.....C = 15.14; H = 2.88; P = 26.30 per cent.
Second " " ......C = 15.01; H = 2.92; P = 26.84 " "
Calculated for $C_6H_{12}O_{16}P_4$.....C = 15.51; H = 2.58; P = 26.72 " "

Preparation of the Acid

The free acid was prepared from 3 grams of the globular salt. The barium was removed with a slight excess of sulfuric acid and the barium sulfate filtered off. The filtrate was precipitated with an excess of copper acetate, filtered, and washed free of sulfates. The copper salt was decomposed in aqueous suspension by hydrogen sulfide. The copper sulfide formed an exceedingly persistent colloidal

solution which it was very difficult to break up and so much time was consumed in this operation that some hydrolysis of the acid occurred, as shown by the fact that its dilute solution gave a white precipitate with ammonium molybdate which gradually turned yellow in color. Equally poor success was experienced with a second preparation of the free acid in which lead was substituted for copper. After the copper sulfide had finally been removed the solution was concentrated under reduced pressure at a temperature not exceeding 40° and then dried in vacuum over sulfuric acid. The acid was obtained as a colorless thick syrup which quickly dried forming a hard brittle mass. It was readily soluble in water and alcohol and it showed no tendency whatever to crystallize. The addition of ether to the alcoholic solution of the acid caused it to separate as small oily drops.

The acid was analyzed after drying to constant weight in vacuum at 78° over phosphorus pentoxide. On drying at this temperature the acid darkened slightly in color indicating some decomposition.

0.1464 gm. substance gave 0.0370 gm. H_2O and 0.0813 gm. CO_2.
0.1588 " " 0.1480 gm. $Mg_2P_2O_7$.
Found: C = 15.15; H = 2.89; P = 25.97 per cent.
0.1565 gm. of the dry acid dissolved in 50 cc. of water required 15.4 cc. of 0.1 N NaOH using phenolphthalein as indicator.
For $C_6H_8O_6\ [P_2O_3(OH)_2]_3$, calculated: 13.5 cc. of 0.1 N NaOH.

After titrating the above, an excess of neutral barium chloride was added which caused a white precipitate of the barium salt and, at the same time, an increase in the acidity which required 5.9 cc. of 0.1 N NaOH for neutralization. If we assume that the two free alcoholic hydroxyls in the inosite ring became acidic by reason of the presence of the adjacent acid molecules a hexa-basic acid would then be formed. For $C_6H_6(OH)_2O_4\ [P_2O_3(OH)_2]_2$, calculated: 20.2 cc. of 0.1 N NaOH. As will be noticed, an excess of alkali was required but this was probably due to the slight hydrolysis of the acid during the preparation, of which mention has been made.

Properties of the Free Acid

The aqueous solution of the acid gave white amorphous precipitates on adding silver nitrate, barium chloride, or calcium chloride. Magnesium chloride gave no precipitate in the cold but on warming a white precipitate was formed which redissolved on cooling. Copper sulfate in excess gave a bluish white precipitate. Ferric chloride gave a yellowish white precipitate which was very insoluble in hydrochloric acid. A dilute solution of the acid immedidately precipitated egg albumin. As stated before ammonium molybdate produced, even in dilute solutions, a white flocculent precipitate either immediately or on warming. This precipitate,

owing apparently to partial hydrolysis of the acid during its preparation, gradually turned yellow in color when the solution was warmed.

Phytic acid is not precipitated from aqueous solutions by barium or calcium chlorides. Ammonium molybdate produces a white granular or crystalline precipitate with phytic acid only in concentrated solution.

Preparation of the Silver Salt

An aqueous solution of the acid was nearly neutralized with ammonia and then acidified by adding a few drops of nitric acid. Silver nitrate was added in slight excess and the white amorphous precipitate was filtered, washed in water and alcohol and ether, and dried in vacuum over sulfuric acid. The resulting silver salt was a nearly white amorphous substance which was very slightly sensitive to light and on moist litmus paper it showed only a faint acid reaction.

The salt was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.2584 gm. substance gave 0.0257 gm. H_2O and 0.0773 gm. CO_2.
0.2359 " " " 0.1497 gm. AgCl and 0.1156 gm. $Mg_2P_2O_7$.
Found: C = 8.15; H = 1.11; P = 13.66; Ag = 47.76 per cent.
For $C_6H_8O_{16}P_4Ag_4$, calculated: C = 8.07; H = 0.89; P = 13.91; Ag = 48.40 per cent.

Hydrolysis of the Synthetic Preparation Into Inosite and Phosphoric Acid

The barium salt was hydrolyzed by heating in an autoclave to 140–150° for 2½ hours with dilute sulfuric acid. After cooling, the inosite was isolated in the usual way and recrystallized several times from water with the addition of alcohol. The quantity of pure recrystallized inosite which was obtained corresponded to 84 per cent of the theoretical amount. The substance gave the reaction of Scherer and melted at 223° (uncorrected). That it was pure inosite was shown by its crystal form, melting point, and the Scherer reaction, and analysis was therefore omitted.

II. COMPOSITION OF INOSITE PHOSPHORIC ACID OF PLANTS

INTRODUCTION

A number of investigators have isolated and studied inosite phosphoric acid compounds derived from seeds and various feeding material. (See Anderson, 1919, and Rose, 1912.) Unfortunately, there is no agreement among these investigators as to the composition of the phytic acid or inosite phosphoric acid, nearly every worker in this field having found one or more substances which differ in composition from those analyzed by others.

Posternak (1903 a, b, and c), who first carefully studied this substance, concluded from his data of the analyses of crystalline double calcium-sodium salts that phytin was a salt of an acid having the formula $C_2H_8O_9P_2$. On theoretical grounds Neuberg (1908) suggested that this formula should be multiplied by 3, *viz* $C_6H_{24}O_{27}P_6$. On equally theoretical grounds it was assumed by Suzuki and collaborators (1907) that the acid was an hexaphosphoric acid ester of inosite, $C_6H_{18}O_{24}P_6$. Starkenstein (1910), Vorbrodt (1910), and others elaborated more complex formulas for the acid. Patten and Hart (1904) and Hart and Tottingham (1909) regarded the substances which they analyzed as identical with the phytin of Posternak.

In earlier papers from this laboratory (1912a) it was assumed that the phytic acid formula according to Posternak and Neuberg was correct, and the analytical data from amorphous phytin preparations were in close agreement with this formula. But in isolating the organic phosphoric acid of cottonseed meal (1913), we were able to obtain crystalline barium salts which corresponded closely in composition to salts of inosite hexaphosphoric acid. Identical crystalline salts were later obtained from oats, corn, commercial phytin (1914a), wheat bran (1915d), and more recently from maple seed.[1]

These barium salts had been very carefully purified by repeated recrystallization until the composition remained constant. Two types of barium salts were obtained corresponding to the following formulas, $C_6H_{12}O_{24}P_6Ba_6$ and $(C_6H_{11}O_{24}P_6)_2Ba_7$. The first or tribarium inosite hexaphosphate crystallizes slowly in rosettes of microscopic needles after addition of alcohol to a solution of the barium salt in dilute hydrochloric acid. The second salt, which may be regarded either as a hepta-barium inosite hexaphosphate or as a mixture of equal parts of tri- and tetrabarium inosite hexaphosphate, is obtained on heating a solution of the barium salt in dilute hydrochloric acid in the presence of an excess of barium chloride, or it separates slowly as a heavy powder or crystalline

[1] An account of this work will be published later.

crust when a dilute hydrochloric acid solution of the barium salt containing a large excess of barium chloride is allowed to stand at room temperature.

Thompson (1915) obtained similar crystalline barium salts from the inosite phosphoric acid of rice bran and Robinson and Mueller (1915) from wheat bran. Clarke (1914 and 1915) and Boutwell (1917), using similar methods, isolated substances from wild Indian mustard and wheat bran which differed considerably in composition from salts of inosite hexaphosphoric acid. Rather (1913) has expressed the opinion that the preparations which he had isolated were not salts of inosite hexaphosphoric acid but of acids represented by various formulas such as $C_4H_{17}O_{15}P_3$, $C_6H_{17}P_4O_{17}$, and $C_4H_{15}P_3O_{13}$; but later he believed that the composition was best represented by the formula $C_{12}H_{41}O_{42}P_9$. In a more recent publication (1918) it is stated by this author that the composition of the inosite phosphoric acid of plants is equally well expressed either by the formula $C_{12}H_{41}O_{42}P_9$ or by the formula of inosite pentaphosphoric acid, $C_6H_{17}O_{21}P_5$.

It is possible that substances having the composition described by Rather may be isolated from plant material. We believe, however, when inosite penta-, tetra-, or other lower inosite phosphoric acids are found that they have been formed thru partial hydrolysis of the inosite hexaphosphoric acid. Such partial hydrolysis may occur either in the plant material itself during storage as found by Rather (1917) in cottonseed meal and by the writer in maple seed; or else it may occur during the process of isolating the substance thru enzymatic action when the material is digested in water, as shown by Suzuki and collaborators (1907), or on digestion in very dilute acids as shown by the writer (1915c) and later confirmed by Boutwell (1917).

Moreover, the analytical data presented by Rather do not prove conclusively that the composition of the inosite phosphoric acid of plants corresponds to inosite pentaphosphoric acid. It was suggested by the writer some years ago (1915a) that the strychnine salts are not suitable for the identification of inosite phosphoric acid because the great basicity of the acid gives salts of very high molecular weight. Slight differences in composition of the acid can not be determined, therefore, by analysis of such salts for the reason that analytical errors may be greater than the difference in calculated percentage composition. This is illustrated in Table 1. In the first column is given the average of the 16 strychnine salts analyzed by Rather, in the second column the calculated composition of tetra-strychnine inosite pentaphosphate, and in the third column the calculated percentage of a mixture assumed to consist of two parts of penta-strychnine and one part of tetra-strychnine inosite hexaphosphate.

TABLE 1.— COMPARATIVE COMPOSITION OF STRYCHNINE SALTS.

AVERAGE OF 16 ANALYSES REPORTED BY RATHER	CALCULATED FOR TETRA-STRYCHNINE INOSITE PENTAPHOSPHATE, $C_6H_{17}O_{21}P_5(C_{21}H_{22}N_2O_2)_4$	CALCULATED FOR $2\,[C_6H_{18}O_{24}P_6(C_{21}H_{22}N_2O_2)_5]+C_6H_{18}O_{24}P_6(C_{21}H_{22}N_2O_2)_4$
C 55.99 per cent	C 56.36 per cent	C 56.25 per cent
H 5.76 " "	H 5.48 " "	H 5.43 " "
N 5.46 " "	N 5.84 " "	N 5.88 " "
P 8.45 " "	P 8.08 " "	P 8.38 " "

It is self-evident that such slight differences in percentage composition as exist between the above formulas can not be determined accurately by analysis. Having due regard for the limit of error in analytical work, we do not believe that the data of the above author present any definite proof that inosite pentaphosphoric acid exists in plants.

Posternak (1919 a and b) has recently called attention to his earlier work and again he describes the crystalline double calcium-sodium salt which he analyzed several years ago. At the present time this author accepts the phytic acid formula proposed by Neuberg, *viz* $C_6H_{24}O_{27}P_6$. This formula differs from that of inosite hexaphosphoric acid by containing three molecules more of H_2O, $C_6H_{18}O_{24}P_6+3H_2O=C_6H_{24}O_{27}P_6$. In what manner these three molecules of water are combined in the acid is not explained. Posternak not only believes that the phytic acid existing in plant material has this formula but he claims to have synthesized an identical acid (1919c) by heating a mixture of inosite, phosphoric acid, and phosphorus pentoxide.

On repeating these experiments on the synthesis of phytic acid, the writer was unable to confirm the conclusion of Posternak that inosite hexaphosphoric acid or phytic acid was formed. The only product which he could isolate from the reaction mixture corresponded to the formula $C_6H_{12}O_{16}P_4$, which is evidently an inosite ester of pyrophosphoric acid. This new acid possesses very nearly the same percentage of phosphorus as phytic acid, but in properties and reactions it differs from this substance in several particulars.

In view of the disparity in the results of the several investigators, Patten and Hart, Clarke, Boutwell, Rather, Robinson and Mueller, and the writer, as to the composition of the phytic acid of wheat bran, this substance has been re-investigated.

It was noticed in this laboratory that when wheat bran is digested in about 0.2 per cent hydrochloric acid that compounds differing in composition from inosite hexaphosphoric acid are obtained (1912b). From this mixture of organic phosphoric acids we were able to identify two, inosite monophosphoric acid (1914b) and inosite

triphosphoric acid (1915a). It was found later, however, on digesting wheat bran in 0.5 or 1.0 per cent hydrochloric acid that salts of inosite hexaphosphoric acid (1915d) were obtained, and it was also found that the stronger acid destroyed the enzyme phytase which hydrolyzed the inosite hexaphosphoric acid when the bran was digested in 0.2 per cent hydrochloric acid.

In the present investigation it was found that the crystalline barium salts corresponded very closely in composition to those previously obtained from this material. The work fully confirms not only our earlier results with respect to the composition of the phytic acid of wheat bran, but the results are also in agreement with the preparations isolated from cottonseed meal, commercial phytin, oats, corn, and maple seed which have been reported from this laboratory.

The relation of carbon to phosphorus in all of these carefully purified and many times recrystallized barium salts is in the ratio of 6:6. The percentage of phosphorus is slightly higher and the percentage of carbon is slightly lower than is required by the phytic acid formula of Posternak. We have been forced to the conclusion, therefore, that the assumption of Suzuki and collaborators, that phytic acid is inosite hexaphosphoric acid, $C_6H_{18}O_{24}P_6$, is correct.

EXPERIMENTAL

Preparation of the Barium Salt

The usual procedure of isolating the substance from the wheat bran was slightly modified. The following method, which was found to be the most satisfactory, is here briefly described. The wheat bran, 3 kilograms, was digested in 12 liters of 2 per cent hydrochloric acid for five hours with frequent stirring. It was then strained thru cheese cloth and the extract was freed from suspended starch, etc., by centrifuging and finally by filtering thru a layer of paper pulp. To the clear filtrate was added sufficient sodium acetate to bind the free hydrochloric acid. The phosphorus compounds were then precipitated by adding a concentrated solution of barium chloride until no further precipitate was produced. After settling, the supernatant liquid was syphoned off and the barium salt was freed from the mother liquor by centrifuging and then filtering and washing with water on a Buchner funnel.

The washed precipitate was suspended in water and the barium was removed by adding a slight excess of sulfuric acid. After the barium sulfate had settled, it was filtered off and the clear filtrate was precipitated by adding a solution of copper acetate. The resulting copper salt was filtered and washed free of sulfates with water and was then suspended in water and decomposed with hydrogen sulfide. The copper sulfide was removed and the filtrate

freed from excess of hydrogen sulfide with a current of air and then precipitated by adding a solution of barium hydrate. The barium salt was filtered and washed thoroly with water. It was dissolved in dilute hydrochloric acid, filtered, and re-precipitated with barium hydrate. After precipitating in this manner seven times with barium hydrate, the substance was precipitated four times with alcohol from dilute hydrochloric acid. It was finally filtered and washed free of chlorides with dilute alcohol and alcohol and ether, and dried in vacuum over sulfuric acid. The substance was a snow-white, bulky, crystalline powder and it gave no reaction with ammonium molybdate indicating absence of inorganic phosphate. It weighed 95 grams. Bases other than barium were absent.

For the purpose of removing any oxalic acid which might have been retained, the substance was dissolved in dilute hydrochloric acid and to it was added a concentrated solution of 20 grams of barium chloride. After standing over night the slight precipitate which had formed was filtered off and the filtrate precipitated by adding an equal volume of 95 per cent alcohol. The substance was filtered and washed in dilute alcohol until free from chlorides and then washed in alcohol and ether and dried in vacuum over sulfuric acid.

The substance was further crystallized as follows: It was dissolved in dilute hydrochloric acid and the free acid nearly neutralized by adding, with constant shaking, a dilute solution of barium hydrate until a faint permanent cloudiness remained. The solution was filtered and alcohol was added slowly with shaking until a slight permanent precipitate was produced. The solution was again filtered and a few grams of barium chloride were added and the whole allowed to stand at room temperature for 24 hours. The barium salt separated slowly as a compact mass consisting of rosettes or globular masses of microscopic needles. The substance was recrystallized in this manner three times. The crystalline precipitate was finally washed in dilute alcohol until free from chlorides and then in absolute alcohol and ether. For analysis portions of this material were further recrystallized as indicated below.

Preparation of Hepta-barium Inosite Hexaphosphate

Ten grams of the above substance were dissolved in dilute hydrochloric acid, the free acid was nearly neutralized with a dilute solution of barium hydrate, and the solution filtered. To this was added 10 grams of barium chloride and the solution was allowed to stand at room temperature for two days. The substance separated slowly as a heavy compact crystalline crust which consisted of small rosettes of microscopic needle-shaped crystals. It was recrystallized a second time in the same way and was then filtered, washed with water until free from chlorides, and finally washed in alcohol and ether and dried in the air.

For analysis the substance was dried at 105° in vacuum over phosphorus pentoxide. It lost on drying 10.91 per cent H_2O.

Found: C = 6.25; H = 1.16; P = 16.32; Ba = 42.55 per cent.

A second preparation recrystallized as above gave the following result:

Found: C = 6.42; H = 1.22; P = 16.34; Ba = 42.55; H_2O = 9.71 per cent.
Calculated for $(C_6H_{11}O_{24}P_6)_2Ba_7$ 14 H_2O:
C = 6.35; H = 0.97; P = 16.40; Ba = 42.39; H_2O = 10.00 per cent.

Preparation of Tri-barium Inosite Hexaphosphate

Ten grams of the purified barium salt were dissolved in dilute hydrochloric acid and the filtered solution was precipitated by adding an equal volume of 95 per cent alcohol. The amorphous precipitate after standing for about 24 hours in contact with the mother liquor assumes a crystalline form which appears to be identical with that described above, i. e., it consists of very minute rosettes of microscopic needles. It was then filtered and washed with 30, 50, and 95 per cent alcohol until free from chlorides and after displacing the alcohol with ether the substance was dried in vacuum over sulfuric acid. The product was recrystallized three times in this manner. It was obtained as a snow-white, bulky, crystalline powder which gave no reactions for either chlorides or inorganic phosphate.

For analysis it was dried in vacuum at 105° over phosphorus pentoxide.

Found: C = 6.73; H = 1.69; P = 16.93; Ba = 38.60 per cent.
Found: C = 6.79; H = 1.30; P = 17.10; Ba = 39.00 per cent.
Calculated for $C_6H_{12}O_{24}P_6Ba_3$:
C = 6.75; H = 1.12; P = 17.44; Ba = 38.65 per cent.

Preparation of the Silver Salt

Three grams of the recrystallized hepta-barium salt were suspended in water and the barium precipitated with a slight excess of sulfuric acid. After filtering off the barium sulfate the solution was precipitated with copper acetate. The copper salt was filtered, washed, suspended in water, and decomposed with hydrogen sulfide. After filtering off the copper sulfide and removing the excess of hydrogen sulfide with a current of air a colorless solution of the free acid was obtained. Ten cubic centimeters of this filtrate were titrated with 0.1 N NaOH and the calculated quantity of ammonia was added to the balance of the solution. This produced a slightly alkaline reaction. Silver nitrate was added in slight excess. The heavy white precipitate of the silver salt was filtered and washed thoroly in water and then dried in vacuum over sulfuric acid. The silver salt was a nearly white, heavy, amorphous powder.

It was analyzed after drying at 105° in vacuum over phosphorus pentoxide. It turned quite dark in color on drying.

Found: C = 3.82; H = 0.49; P = 9.56; Ag = 66.08 per cent.
P = 9.57; Ag = 66.18 per cent.
Calculated for $C_6H_6O_{24}P_6Ag_{12}$:
C = 3.70; H = 0.30; P = 9.57; Ag = 66.64 per cent.

Another silver salt was prepared in the same way as above except that it was made from a phytic acid preparation which had been purified as a crystalline strychnine salt.

Found: C = 3.90; H = 0.54; P = 9.48; Ag = 66.56 per cent.

These preparations are apparently neutral silver salts of inosite hexaphosphoric acid. All other silver salts which have been prepared and analyzed have been acid salts. It was hoped that a neutral ester of inosite hexaphosphoric acid might be obtained by the action of methyl iodide upon the neutral silver salt. However, all attempts to prepare such an ester were unsuccessful and only strongly acid syrups were obtained.

LITERATURE CITED

Anderson, R. J.

1912 a Phytin and phosphoric acid esters of inosite. *Jour. Biol. Chem.* 11, *471;* 12, *97. Also N. Y. Agr. Exp. Sta. Tech. Bul. Nos. 19 and 21.*

1912 b The organic phosphoric acid compound of wheat bran. *Jour. Biol. Chem.* 12, *447;* 18, *(1914) 425. Also N. Y. Agr. Exp. Sta. Tech. Bul. Nos. 22, 1912; 36, 3–16, 1914.*

1913 The organic phosphoric acid of cottonseed meal. *Jour. Biol. Chem.* 13, *311;* 17, *(1914), 141. Also N. Y. Agr. Exp. Sta. Tech. Bul. Nos. 25, 1912; 32, 4–11, 1914.*

1914 a Contributions to the Chemistry of phytin. *Jour. Biol. Chem.* 17, *141, 151, 165, 171. Also N. Y. Agr. Exp. Sta. Tech. Bul. No. 32, 12–44.*

1914 b Concerning inosite monophosphate. A new organic phosphoric acid occurring in wheat bran. *Jour. Biol. Chem.* 18, *441. Also N. Y. Agr. Exp. Sta. Tech. Bul. No. 36, 16–20.*

1915 a The organic phosphoric acid of wheat bran. The occurrence of inosite tri-phosphoric acid in wheat bran. *Jour. Biol. Chem.* 20, *463. Also N. Y. Agr. Exp. Sta. Tech. Bul. No. 40, 4–13.*

1915 b The hydrolysis of phytin by the enzyme phytase contained in wheat bran. *Jour. Biol. Chem.* **20**, *475*. *Also N. Y. Agr. Exp. Sta. Tech. Bul. No. 40, 13–18.*

1915 c The hydrolysis of the organic phosphorus compound of wheat bran by the enzyme phytase. *Jour. Biol. Chem.* **20**, *483*. *Also N. Y. Agr. Exp. Sta. Tech. Bul. No. 40. 18–25.*

1915 d Phytin in wheat bran. *Jour. Biol. Chem.* **20**, *494*. *Also N. Y. Agr. Exp. Sta. Tech. Bul. No. 40, 25–31.*

1919 The occurrence of organic phosphorus compounds in plants. *Thesis, Cornell Univ., May, 1919.*

Boutwell, P. W.
1917 The phytic acid of the wheat kernel and some of its salts. *Jour. Am. Chem. Soc.* **39**, *491*.

Carré, P.
1911 Contardi's polyphosphoric acid esters of inosite, mannite, quercite, and glucose. *Bul. Soc. chim.* **9**, *195*.

Clarke, Geo.
1914 Phytin and phytic acid. *Jour. Chem. Soc. (London)* **105**, *535*.

1915 The organic phosphoric acid of wheat. *Jour. Chem. Soc. (London)* **107**, *360*.

Contardi, A.
1909 Synthesis of the phospho-organic acid of the seeds of plants (Posternak's anhydro-oxymethylene diphosphoric acid). *Atti. R. Acc. Lincei, ser. 5*, **18**, *64*.

Hart, E. B., and Tottingham, W. E.
1909 The nature of the acid-soluble phosphorus compounds of some important feeding materials. *Jour. Biol. Chem.* **6**, *431*.

Jegorow, M. A.
1914 Zur Kenntnis der Eigenschaften des Phytins. *Biochem. Zeitschr.* **61**, *41*.

Neuberg, Carl.
1908 Zur Frage der Konstitution des Phytins. *Biochem. Zeitschr.* **9**, *557*.

Patten, A. J., and Hart, E. B.
1904 The nature of the principal phosphorus compound in wheat bran. *Amer. Chem. Jour.* 31, *564.*

Plimmer, R. H. A.
1913 The hydrolysis of organic phosphorus compounds by dilute acids and dilute alkali. *Biochem. Jour.* 7, *72.*

Posternak, S.
1903 a Sur la matière phospho-organique de réserve des plantes à chlorophylle. *Compt. rend. Acad. d. sc.* 137, *202.*

1903 b Sur les propriétés et la matière phospho-organique de réserve des plantes à chlorophylle. *Compt. rend. Acad. d. sc.* 137, *337.*

1903 c Sur la constitution de l'acide phospho-organique de réserve des plantes vertes et sur le premier produit, de reduction du gaz carbonique dans l'acte de l'assimilation carbonique. *Compt. rend. Acad. d. sc.* 137, *439.*

1919 a Sur deux sels cristallisés du principe phospho-organique de réserve des plantes vertes. *Compt. rend. Acad. d. sc.* 168, *1216.*

1919 b Sur la constitution du principe phospho-organique de réserve des plantes vertes. *Compt. rend. Acad. d. sc.* 169, *37.*

1919 c Sur la synthèse de l'éther hexaphosphorique de l'inosite et son identité avec le principe phospho-organique de réserve des plantes vertes. *Compt. rend. Acad. d. sc.* 169, *138.*

Rather, J. B.
1913 Phytic acid in cottonseed meal and wheat bran. *Jour. Amer. Chem. Soc.* 35, *890. Also Texas Agr. Exp. Sta. Bul. No. 156.*

1917 The inosite phosphoric acids of cottonseed meal. *Jour. Amer. Chem. Soc.* 39, *777.*

1918 The nature of the inosite phosphoric acids of some important feeding materials. *Jour. Amer. Chem. Soc.* 40, *523.*

Robinson, C. J., and Mueller, J. H.
1915 The organic phosphorus compounds of wheat bran. *Biochem. Bul.* 4, *100.*

Rose, A. R.
1912 A resumé of the literature on inosite phosphoric acid, with special reference to the relation of that substance to plants. *Biochem. Bul.* 2, *21*.

Starkenstein, Emil.
1910 Die biologische Bedeutung der Inositphosphorsäure. *Biochem. Zeitschr.* 30, *56*.

Suzuki, U., Yoshimura, K., and Takaishi, M.
1907 Ueber ein Enzym "Phytase" das "Anhydro-oxymethylen diphosphorsäure" spaltet. *Bul. Tokyo Imper. Univ. College of Agr.* 7, *503*.

Thompson, Alice R.
1915 Organic phosphoric acid of rice. *Jour. Agr. Research* 3, *425*.

Vorbrodt, W.
1910 Untersuchungen über die Phosphorverbindungen in den Pflanzensamen, mit besonderer Berücksichtigung des Phytins. *Bul. de l'Acad. des sc. de Cracovie, ser. A,* 1910, *414*.

REPORT

OF THE

Department of Botany

F. C. Stewart, *Chief in Research (Botany).*

W. O. Gloyer, *Associate in Research (Botany).*

M. T. Munn, *Associate Botanist.*

Elizabeth F. Hopkins, *Assistant Botanist.*

TABLE OF CONTENTS

REPORT OF THE DEPARTMENT OF BOTANY

EXPERIMENTS ON THE SPACING OF POTATO PLANTS*

F. C. STEWART

SUMMARY

The principal object of the experiments here described was to determine the feasibility of employing close planting in the production of seed potatoes as a means of improving the quality of the crop thru a reduction in the average size of the tubers.

The experiments were conducted at Geneva during five seasons and devoted, chiefly, to a comparison of 6- by 36-inch planting with 15- by 36-inch planting. The soil was a heavy clay loam of medium fertility. The variety Sir Walter Raleigh was used in 1914, 1915, 1917, and 1918, and Enormous No. 9 in 1919. Rows of thick and thin planting were alternated. At harvest time, the product of each row was sorted, according to weight, into four grades and the tubers of each grade weighed and counted. The grades were: (1) Under one ounce; (2) from one to two ounces; (3) from two to twelve ounces; and (4) over twelve ounces.

In different seasons, the total number of tubers over one ounce in weight varied from 41,847 to 62,600 per acre for thin planting, and from 71,603 to 97,150 per acre for thick planting. The difference in favor of thick planting varied from 29,281 to 34,550 tubers per acre.

In total quantity of tubers over one ounce in weight, the yield varied, in different seasons, from 144.5 to 340.8 bushels per acre for thin planting and from 191.8 to 384.4 bushels per acre for thick planting. The difference in net yield (total yield minus seed) of tubers over one ounce in weight varied from 24.9 to 46.6 bushels per acre, and averaged 34.7 bushels per acre, in favor of thick planting. Over one half of this difference (18.7 bushels) consisted of tubers over two ounces in weight.

* Reprint of Bulletin No. 474, April, 1920.

The average weight of tubers over two ounces in weight was reduced from 10.5 to 22.8 per cent by thick planting. For table use, the size of the tubers of the crop from thick planting was superior to that from thin planting in 1914 and 1919, but in the other three seasons the tubers from thin planting were the better in this respect.

The results of the experiment appear to warrant the following conclusions: In the production of seed potatoes of varieties of the Rural group, New York growers may well consider planting considerably closer than 15 by 36 inches, since; thereby, the net yield is likely to be increased and the quality of the crop improved, particularly on rich soil. In the home seed-plat the spacing in the row should be as close as is consistent with roguing; but if the crop is to be sold the difficulty in disposing of the small tubers may necessitate somewhat thinner planting, except on rich soil. Potatoes grown in rich garden soil, for table use, may be planted as close as 6 by 30 inches with advantage.

INTRODUCTION

In the spacing of potato plants the practise of New York potato growers varies greatly. Even under similar conditions in the same locality there is a very noticeable lack of agreement as to the kind of spacing which gives the best results. Some growers plant in drills others in checkrows. The distance between rows varies from 30 to 39 inches and the distance between plants in the row from 9 to 36 inches.

Undoubtedly, the best spacing will vary somewhat for different conditions. Some varieties require closer planting than others. On rich soil one should plant closer than on poor soil. When the land is very weedy it may be necessary to plant so that the crop may be cultivated in both directions.

Probably, the size of the seed-pieces used should be taken into account. The spacing which gives best results in a wet season may not be the best for a dry season; and one adapted to a growing season of normal length may not meet the requirements when, because of late planting, a severe attack of blight, or an early frost, the growing season is very short. The many factors which enter into the problem make it quite complicated.

It appears that the practise of growers is based upon personal experience and observation rather than upon the results of carefully planned experiments. While a considerable number of experiments have been made the results obtained have been of very limited application, and few such experiments have been either well planned or properly executed.

OBJECT OF THE GENEVA EXPERIMENTS

The experiments described in this bulletin had their origin in an attempt to improve the quality of seed potatoes. Under the usual methods of planting in Western New York, varieties of the Rural group, such as Rural New Yorker No. 2, Sir Walter Raleigh, Enormous No. 9, etc., produce many tubers which are too large to be desirable for seed purposes. Tubers weighing over twelve ounces are undesirable for seed because of the waste in cutting them to fit the planter.

There are good reasons for believing that, in any given hill, the small tubers are as productive, weight for weight, when planted, as the large tubers. In fact, tubers weighing between one and two ounces make the very best of seed because they may be planted without cutting. This being true, it is worth while to consider means of increasing the proportion of small and medium sized tubers. If, by thicker planting, the average size of the tubers can be reduced without reducing the total net yield, it may be advisable to employ thick planting of potatoes designed for seed production as a means of improving the quality of the crop.

It is quite possible, also, that thru a better understanding of the effects of different spacings, a better quality of table potatoes may be produced without sacrificing quantity. Medium sized tubers are preferred for table use.

THE FIELD EXPERIMENT OF 1914

In this experiment there were twenty-eight rows seventy-eight feet long by three feet wide. There was, also, an outside or buffer row on each side of the experiment plat. The twenty-eight rows were divided into seven series of four rows each. In each series the seed-pieces were six inches apart in the first row, nine inches apart in the second row, twelve inches apart in the third row, and fifteen

inches apart in the fourth row. The average weight of the seed-pieces being 1.029 ounces, it required 31.12 bushels of seed per acre for the six-inch planting, 23.34 bushels for the nine-inch planting, 15.56 bushels for the twelve-inch planting, and 12.45 bushels for the fifteen-inch planting. The seed-pieces were accurately spaced in open furrows by means of ruled rods and covered by means of hoes. The date of planting was June 2 and the variety Sir Walter Raleigh. The soil was clay loam of medium fertility and in the spring, before planting, it was given a light coat of stable manure, but no commercial fertilizer was used.

An almost perfect stand was obtained, the plants being healthy and making a normal growth. The rainfall was ample thruout the season so that the plants attained large size and on September 3 nearly covered the ground between the rows. At this time, it was observed that it was almost impossible to distinguish, either by the mass of foliage or by its appearance, the rows in which the seed-pieces had been planted six inches apart from those in which they had been planted fifteen inches apart.

By spraying them with bordeaux mixture and paris green the plants were thoroly protected against injury by blight and insects. Growth continued until about the middle of October when the plants died naturally without being injured by frost.

At digging time, the product of each row was divided into three grades, according to the weight of the tubers, and a record made of the number and total weight of tubers in each grade. Grade 1 included tubers weighing less than two ounces; Grade 2, tubers between two and twelve ounces; and Grade 3, tubers over twelve ounces. The yield by rows is shown in Table 1.

DISCUSSION OF TABLE 1

Considering the figures in the next to the last column, which show the total number of tubers of all grades produced by each row, it is seen that with an increase in thickness of planting there was a very definite, tho somewhat irregular, increase in the number of tubers produced, except in one instance, namely, in the case of Row 14. This row, in which the seed-pieces were nine inches apart, yielded only 400 tubers; whereas Row 15, in which the seed-pieces were twelve inches apart, yielded 414 tubers.

The total weight of the crop, given in the last column, also shows a strong tendency to increase with an increase in the thickness of planting, but the increase here is neither as constant nor as regular as with the number of tubers.

TABLE 1.— YIELD BY ROWS IN 1914 FIELD EXPERIMENT: NUMBER AND WEIGHT OF TUBERS.

Row *	Spacing in row	No. tubers 1–2 oz.†	Tubers under 2 oz.			Tubers 2–12 oz.			Tubers over 12 oz.			Tubers of all grades		
			No.	Weight		No.	Weight		No.	Weight		No.	Weight	
	In.			*Lbs.*	*Oz.*		*Lbs.*	*Oz.*		*Lbs.*	*Oz.*		*Lbs.*	*Oz.*
1...	6	84	160	10	10	395	106	14	3	2	10	558	120	2
2...	9	40	77	5	7	307	99	10	21	20	6	405	125	7
3...	12	31	60	4	10	309	112	14	17	16	10	386	134	2
4...	15	11	25	1	8	227	90	10	28	25	6	280	117	8
5...	6	....	108	7	14	349	112	4	6	5	4	463	125	6
6...	9	....	76	5	8	294	101	9	8	7	7	378	114	8
7...	12	....	57	3	12	303	103	0	6	5	8	366	112	4
8...	15	....	32	2	3	243	91	8	24	22	8	299	116	3
9...	6	67	113	8	2	396	121	14	2	1	10	511	131	10
10...	9	42	94	5	15	303	100	14	11	10	2	408	116	15
11...	12	35	58	4	2	277	101	8	12	11	0	347	116	10
12...	15	30	64	4	2	254	88	12	17	15	4	335	108	2
13...	6	81	137	10	4	387	113	2	5	4	6	529	127	12
14...	9	37	80	5	8	310	107	0	10	8	8	400	121	0
15...	12	36	84	5	6	325	105	2	5	4	14	414	115	6
16...	15	35	70	4	6	271	96	7	14	12	1	355	112	14
17...	6	90	166	11	12	414	114	2	2	1	14	582	127	12
18...	9	33	102	5	8	364	105	2	3	2	14	469	113	8
19...	12	38	87	5	1	314	101	14	4	3	2	405	110	1
20...	15	38	92	5	4	284	88	8	15	13	0	391	106	12
21...	6	55	137	8	0	404	110	3	2	1	13	543	120	0
22...	9	43	102	6	0	337	107	0	11	9	8	450	122	8
23...	12	35	66	4	4	310	102	12	13	12	4	389	119	4
24...	15	24	45	3	1	242	86	8	24	20	0	311	109	9
25...	6	89	173	11	10	396	114	14	2	1	10	571	128	2
26...	9	57	126	7	14	354	108	8	7	6	8	487	122	14
27...	12	27	72	4	10	308	108	0	6	5	8	386	118	2
28...	15	24	49	3	2	260	106	8	26	30	8	335	140	2

* Number of rows required to make an acre, 186.15.

† The total weight of tubers of this grade was not obtained separately from that of tubers under one ounce in weight. The tubers from Rows 5, 6, 7, and 8 were accidentally mixed before they had been counted. The total number was 146.

In all of the seven sections, excepting the last one, six-inch planting gave a larger yield than fifteen-inch planting. The last row of

Section 7 (Row 28), altho a fifteen-inch row, yielded twelve pounds, or 9.4 per cent, more than Row 25, a six-inch row in the same section. It seems probable that the yield of Row 28 was abnormally high since it was 19.3 per cent higher than the yield of any other fifteen-inch row in the experiment. The writer is of the opinion that the high yield of Row 28 was due to some unknown advantage which it possessed and that it would be unfair to include the yield of this row when calculating the average yield of the fifteen-inch plantings. In fact, all four rows of Section 7 should be rejected. Likewise, Section 1, comprising Rows 1, 2, 3, and 4, should be rejected because the yield of these rows must have been unequally affected by a row of peach trees nearby. Accordingly, in the calculation of the average yield per acre for thick and thin planting, shown in Table 2, the rows of Sections 1 and 7 have been excluded from consideration.

In each section the number and weight of tubers under two ounces and of tubers between two and twelve ounces was greater from six-inch planting than from fifteen-inch planting. Usually, nine- and twelve-inch planting gave yields intermediate between those of six- and fifteen-inch planting (Rows 11 and 19 being exceptions), but the yield of twelve-inch planting was sometimes higher than that of nine-inch planting.

In the class of extra large tubers (over twelve ounces), six-inch planting invariably gave a much smaller number and weight than fifteen-inch planting, while the yields from nine- and twelve-inch planting occupied an intermediate position. In three sections nine-inch planting outyielded twelve-inch planting, while in the other four sections twelve-inch planting outyielded nine-inch planting.

It is the opinion of the writer that the irregularities and discrepancies in the yields in this experiment are so large and so numerous that we are not warranted in drawing from them any conclusions as to the relative merits of nine-inch and twelve-inch planting. Whatever differences there may be between them have been hidden by the inequality in soil and other conditions. The experiment was on too small a scale, the rows were too short, and the different kinds of planting repeated too few times. Accordingly, only the results from six-inch and fifteen-inch plantings are included in the summary (Table 2). Probably, a comparison of these is worth while, but it should be borne in mind that a large allowance must be made for experimental error.

TABLE 2.—MEAN YIELDS PER ACRE IN 1914 FIELD EXPERIMENT: SUMMARY (IN PART) OF DATA IN TABLE 1.

SPACING	NO. OF TUBERS 1-2 OZ.*	TUBERS UNDER 2 OZ.		TUBERS 2-12 OZ.		TUBERS OVER 12 OZ.		TUBERS OF ALL GRADES	
		Number	Quantity	Number	Quantity	Number	Quantity	Number	Quantity
6-inch:			Bu.		Bu.		Bu.		Bu.
Rows 5, 9, 13, 17, and 21..	†13,635	24,609	28.5	72,598	354.9	633	9.3	97,840	392.7
15-inch:									
Rows 8, 12, 16, 20, and 24..	‡5,910	11,281	11.8	48,175	280.2	3,500	51.4	62,956	343.4

* For this grade, only the number of tubers can be given. The total weight of tubers weighing between one and two ounces was not taken separately from that of tubers under one ounce in weight.
† Calculated from the yield of Rows 9, 13, 17, and 21.
‡ Calculated from the yield of Rows 12, 16, 20, and 24.

DISCUSSION OF TABLE 2

In total yield, thick planting outyielded thin planting by 34,884 tubers or 49.3 bushels per acre. This increase in favor of thick planting was all in the two smaller grades of tubers. In fact, in the largest grade, thin planting gave the larger yield by 42.1 bushels per acre. This is a noteworthy feature of the experiment. Either for seed or for table use, the crop from thick planting was decidedly superior to that from thin planting because of the smaller number of very large tubers in the former. The average weight of the tubers above two ounces was 4.75 ounces for thick planting and 6.16 ounces for thin planting. In the 2-to-12-ounce grade, thick planting outyielded thin planting by 74.7 bushels per acre.

THE GARDEN EXPERIMENT OF 1914

The garden experiment consisted of six rows forty feet long and thirty inches apart. The soil was deeply and thoroly fitted and made rich by the use of stable manure, but no commercial fertilizer was used. Three varieties of potatoes were employed in the experiment — Carman No. 3, Rural New Yorker No. 2, and Green Mountain. Of each variety, one thick (six-inch) and one thin (fifteen-inch) row was planted. The seed-pieces were made as

nearly the same size as could be done conveniently, but were not weighed. Probably, the rate of seeding was about sixteen bushels per acre for thin planting and forty bushels per acre for thick planting. Planting was done on May 23 in furrows of uniform depth. Care was taken to place the seed-pieces in thick rows exactly six inches apart and those in thin rows fifteen inches apart.

A perfect stand of plants was obtained. In the Green Mountain variety eight plants on the thick row and two on the thin row were somewhat affected with leaf roll, also, three other plants in the thin row were severely affected with mosaic. In the Rural New Yorker variety there were no diseased plants. In the Carman variety there were two dwarf plants — one in the thick row and one in the thin row.

The plants were given very thoro cultivation and thoro spraying and were not injured by blight or insects. During a spell of hot weather in July the plants were watered once artificially by means of a rotary sprinkler so that they did not suffer for lack of water, but, nevertheless, they showed considerable tipburn in September. The plants attained fair size, but were not extra large. The Green Mountain plants died earlier than the other varieties which finished growth about October 1.

At digging time, the tubers produced on each row of the varieties Rural New Yorker No. 2 and Carman No. 3 were sorted into two grades, those weighing over two ounces going into one grade and those weighing less than two ounces into the other grade. The tubers of each grade were counted and weighed. In the variety Green Mountain the tubers were sorted as in the other varieties and the number in each grade recorded; but, by mistake, the weights of the two grades were not taken separately. For this variety, the only weight we have is that of the total yield.

The actual yields per row and the calculated yields per acre are shown in Table 3.

DISCUSSION OF TABLE 3

In the variety Rural New Yorker No. 2 the thick planting outyielded the thin planting at the rate of 141.6 bushels of large tubers and 7.3 bushels of small tubers per acre. The average weight of the tubers above two ounces in weight was 5.12 ounces for thick planting and 5.71 ounces for thin planting.

Table 3.—Yields in 1914 Garden Experiment: Number and Weight of Tubers.

Variety	Spacing in row	Yield per row*				Yield per acre			
		Tubers under 2 oz.		Tubers over 2 oz.		Tubers under 2 oz.		Tubers over 2 oz.	
		Number	Weight	Number	Weight	Number	Quantity	Number	Quantity
	In.		*Lbs.*		*Lbs.*		*Bu.*		*Bu.*
Rural N. Y. No. 2	6	36	2.00	228	73.0	15,700	14.52	99,317	529.98
	15	14	1.00	150	53.5	6,098	7.26	65,340	388.41
Carman No. 3...	6	33	2.18	219	75.0	14,375	15.83	95,396	544.50
	15	11	0.63	155	55.0	4,792	4.57	67,518	399.30
Green Mountain	6	134	?	185	†62.5	58,370	?	80,586	†453.75
	15	73	?	119	†40.5	31,799	?	51,836	†294.08

* Number of rows required to make an acre, 453.6.
† Total yield. The large and small tubers were not weighed separately.

In the variety Carman No. 3 thick planting showed an advantag of 145.2 bushels of large potatoes plus 11.3 bushels of small potatoe per acre. The average weight of tubers above two ounces in weight was 5.48 ounces for thick planting and 5.68 ounces for thin planting.

Altho the difference in yield from the thick and thin planting of these two varieties was very large, the tubers from the two kinds of planting did not differ in average weight as greatly as did the tubers from thick and thin planting in the field experiment of 1914 where the difference in yield was much smaller. (See p. 287.) This may have been due to the fact that different varieties were used in the two experiments.

The percentage of small tubers was very much greater for Green Mountain than for the other varieties, but it should be observed that it was only about four per cent greater for thick than for thin planting.

The small size of this experiment makes its experimental error very large and it cannot be regarded as having much value.

THE EXPERIMENT OF 1915

The experiment of 1915 comprised ten rows — five thick plantings and five thin plantings alternating. In the thick rows the seed-pieces were placed six inches apart and in the thin rows fifteen inches apart. The rows were 290.4 feet long by three feet wide, and each had an area of one-fiftieth acre. There were, also, two outside or buffer rows — one on either side of the experiment plat. The soil was a heavy clay loam and a liberal application of stable manure was made in the fall before plowing. The seed-potatoes were of the variety Sir Walter Raleigh grown in the experiment of 1914. The average weight of the seed-pieces being 1.721 ounces, the six-inch planting required 52 bushels of seed per acre and the fifteen-inch planting 20.8 bushels per acre. Planting was done on May 25. Accurate spacing of the seed-pieces in the furrows was accomplished by the use of ruled rods. Some difficulty was experienced in covering the seed-pieces uniformly because the soil was quite moist and somewhat lumpy. The covering was done by means of hoes.

There was nearly a full stand. A few plants were missing, but it is not known just how many as no counts were made. The weather being favorable the plants made a rapid growth and covered the ground between the rows completely. Frequent showers brought on an attack of late blight, traces of the disease being found on July 30, and during August it spread rapidly in spite of fair spraying with bordeaux mixture. By September 9 there was very little green foliage left and the growing season of the plants was shortened about three weeks by the disease. Fortunately, very little tuber rot resulted, only an occasional affected tuber being found at digging time. A few of these tubers were so much decayed that they were lost; but most of them were graded, counted, and weighed with the sound tubers.

The tubers from each row were sorted into three grades, namely, (1) under one ounce in weight, (2) between one and two ounces in weight, and (3) over two ounces in weight. It was unnecessary to make a grade for extra large tubers as there were none weighing over twelve ounces. The number and weight of tubers of each grade produced by each row are shown in Table 4.

TABLE 4.—YIELD BY ROWS IN 1915 EXPERIMENT: NUMBER AND WEIGHT OF TUBERS.

Row*	Spacing in row	Tubers under 1 oz.		Tubers 1–2 oz.		Tubers over 2 oz.		Tubers of all grades	
		Number	Weight	Number	Weight	Number	Weight	Number	Weight
	In.		Lbs.		Lbs.		Lbs.		Lbs.
1	6	319.0	12.0	504.0	47.0	1318.0	292.0	2141.0	351.0
2	15	146.0	5.0	305.0	28.0	998.0	237.0	1449.0	270.0
3	6	285.0	11.5	584.0	55.0	1354.0	288.5	2223.0	355.0
4	15	142.0	5.0	229.0	21.0	990.0	238.0	1361.0	264.0
5	6	280.0	11.5	513.0	46.5	1412.0	305.0	2205.0	363.0
6	15	99.0	4.5	252.0	24.0	942.0	229.0	1293.0	257.5
7	6	248.0	9.5	526.0	46.5	1446.0	314.0	2220.0	370.0
8	15	137.0	5.0	286.0	26.5	1048.0	257.5	1471.0	289.0
9	6	270.0	10.5	465.0	42.5	1573.0	363.0	2308.0	416.0
10	15	106.0	3.0	240.0	20.5	970.0	252.0	1316.0	275.5
Average	6	280.4	11.0	518.4	47.5	1420.6	312.5	2219.4	371.0
	15	126.0	4.5	262.4	24.0	989.6	242.7	1378.0	271.2

* Number of rows required to make an acre, 50.

DISCUSSION OF TABLE 4

If we compare the yields of thick and thin planted rows in different parts of the experiment we see at a glance that, in every case, and in all three grades of tubers, the thick planting outyielded the thin planting by a considerable amount. Every one of the thick rows gave a larger yield than either of the two thin rows adjoining it, and no thin row outyielded any thick row in the experiment. This is true both for number of tubers and weight of tubers. In different parts of the experiment the difference in the yields of thick and thin planting varied considerably, this variation being somewhat greater for weight of tubers than for number of tubers. The least difference in the number of tubers occurred in the same place as the least difference in the weight of tubers, namely, between Rows 1 and 2. Likewise, the greatest difference in number of tubers occurred in the same place as the greatest difference in weight of tubers, namely, between Rows 9 and 10.

The writer's opinion of this experiment is that it is a great improvement on the field experiment of 1914, and that it is somewhat better than the 1918 experiment (page 294), but not so good as the 1919 experiment (page 298).

A better idea of the results of the experiment may be obtained from an examination of Table 5 which shows the mean yields in terms of one acre.

TABLE 5.—MEAN YIELDS PER ACRE IN 1915 EXPERIMENT: SUMMARY OF DATA IN TABLE 4.

SPACING IN ROW	TUBERS UNDER 1 OZ.		TUBERS 1–2 OZ.		TUBERS OVER 2 OZ.		TUBERS OF ALL GRADES	
	Number	Quantity	Number	Quantity	Number	Quantity	Number	Quantity
In. 6	14,020	*Bu.* 9.2	25,920	*Bu.* 39.6	71,230	*Bu.* 260.4	111,170	*Bu.* 309.2
15	6,300	3.7	13,120	20.0	49,480	202.2	68,900	226.0

DISCUSSION OF TABLE 5

The total number of tubers produced, 111,170 per acre for thick planting and 68,900 per acre for thin planting, is the largest obtained in any of the experiments except the garden experiment of 1914. This is due, probably, to an abundance of moisture during July and August which was favorable to the setting of tubers.

There was a substantial difference in yield in favor of thick planting in all three grades of tubers. In the grade of marketable tubers (over two ounces) the difference amounted to 21,750 tubers or 58.2 bushels per acre. The average weight of the tubers of this grade was 3.51 ounces for thick planting and 3.92 ounces for thin planting. For table use, the crop from thin planting was, on the whole, superior to that from thick planting. The small average size of the tubers in this experiment is a consequence of the shortening of the growing season by the attack of blight. Had the plants been permitted to finish their growth in a normal manner it is almost certain that the tubers would have been of much larger average size. This experiment is of special interest because it shows the effect of thick planting when the growing season is short.

THE EXPERIMENT OF 1917

The experiment of 1917 was laid out on the same plan as that of 1915, that is to say, five thick rows 290.4 feet long and three feet

apart alternated with five thin rows of the same length, and there was a buffer row on each side of the experiment plat. The soil was a heavy clay loam. The variety used was Sir Walter Raleigh. The potatoes were planted May 31. Seed potatoes being scarce and expensive ($4 per bushel), the seed used in the experiment consisted of whole small tubers weighing between one-half ounce and one ounce. The average weight of the seed tubers was 0.813 ounces. Hence, the rate of seeding was 9.8 bushels per acre for the fifteen-inch planting and 24.5 bushels per acre for the six-inch planting. Soon after planting there came a heavy rain which washed out some of the seed tubers near the north or lower end of the plat. On this account only the yields from portions of four rows can be used in calculating the results.

The soil was rather low in fertility and became hard. The weather was dry. Clearly, the conditions were unfavorable for potatoes. Altho most of the plants were healthy and remained green until killed by frost on October 10, they were of small size. The yields, also, were small. Perhaps the character and small size of the seed-tubers had something to do with the unsatisfactory growth of the plants.

On Rows 7, 8, 9, and 10 there was about 98 per cent of a full stand for a distance of 213.5 feet and it seemed practicable to use the yields of these partial rows for a comparison of the results of thick and thin planting. Table 6 shows the yields of these rows calculated on an acre basis. There being no tubers weighing over twelve ounces the entire crop was divided into three grades as in 1915.

TABLE 6.—YIELDS PER ACRE IN 1917 EXPERIMENT: NUMBER AND QUANTITY OF TUBERS.

Row	Spacing in row	Tubers under 1 oz.		Tubers 1–2 oz.		Tubers over 2 oz.		Tubers of all grades	
		Number	Quantity	Number	Quantity	Number	Quantity	Number	Quantity
	In.		*Bu.*		*Bu.*		*Bu.*		*Bu.*
7	6	9,180	5.3	34,816	49.3	44,336	138.8	88,332	193.4
8	15	6,256	3.5	16,116	24.4	33,116	123.0	55,488	150.9
9	6	12,036	7.6	30,940	48.2	45,424	147.3	88,400	203.1
10	15	5,644	3.6	13,940	19.8	33,184	121.8	52,768	145.2
AVERAGE	6	10,608	6.4	32,878	48.7	44,880	143.0	88,366	198.2
	15	5,950	3.5	15,028	22.1	33,150	122.4	54,128	148.0

DISCUSSION OF TABLE 6

Thruout Table 6 the data are fairly consistent and the difference in yield between thick and thin planting large. There can be no doubt that, under such conditions as surrounded this experiment, six-inch planting gives a considerably larger yield than fifteen-inch planting. It is probable, however, that the mean yields given are only approximations. Two rows having a length of only 213.5 feet are too few for the accurate determination of mean yields. This should be borne in mind when comparing the results obtained in this experiment with those obtained from the experiments of 1915 and 1919 which were more dependable.

The average yield of marketable tubers (over two ounces) from thick planting was greater than that from thin planting by 11,730 tubers or 20.6 bushels per acre. The average weight of the tubers of this grade was 3.06 ounces for thick planting and 3.55 ounces for thin planting. For table use, the crop from thin planting was the better, but even from thin planting there were many tubers which were too small.

This experiment differs from all the others in that the seed consisted of whole small tubers. Hence, in calculating the net yield, the extra quantity of seed used in thick planting should be deducted from the yield of small tubers rather than from the yield of marketable tubers.

THE EXPERIMENT OF 1918

The thick-and-thin experiment conducted in 1918 consisted of twelve rows 290.4 feet long by three feet wide. There were six thick rows in which the seed-pieces were placed six inches apart in the row and, alternating with them, six thin rows in which the seed-pieces were placed fifteen inches apart in the row. No outside or buffer rows were used in this experiment. The soil was a heavy clay loam and was given a light application of stable manure, but no commercial fertilizer. Altho plowed twice, once in the fall and once in the spring, and altho much labor was expended in fitting it, the soil was hard and lumpy at planting time on account of an excessive amount of rain. Nevertheless, by making the furrows shallow and using care in covering the seed-pieces, planting was accomplished in a fairly satisfactory manner.

The seed used was of the variety Sir Walter Raleigh grown in the experiment of 1917. Tubers of medium size were cut into pieces having an average weight of 0.9547 ounces and the pieces were thoroly mixed before planting. The quantity of seed required to plant an acre was 11.53 bushels for the thin rows and 28.82 bushels for the thick rows. The date of planting was June 3.

About 95 per cent of a full stand of plants was obtained. In July it was discovered that about ten per cent of the plants were quite severely affected with leaf roll and a few others were weak from some unknown cause. These conditions were somewhat unfavorable for the experiment.

The weather conditions were not unusual in any respect. During June, July, and September the rainfall was sufficient, but August was too dry for potatoes. About August 1 there were a few days of very hot weather which caused some injury to the plants. Three applications of bordeaux mixture were made. There was no injury by blight or insects except leafhoppers which were quite numerous and caused considerable curling and rolling of the leaves. The plants attained only medium size, never completely covering the ground between the rows. Growth ceased about October 16, or 135 days after planting.

At harvest time the product of each row was sorted into four grades and the tubers of each grade counted and weighed as in the previous experiments. However, there were so few tubers of the extra large grade (over twelve ounces in weight)[1] that it seemed unnecessary to separate them from the next smaller grade and, accordingly, in Tables 7 and 8 the entire crop is reported under three grades.

DISCUSSION OF TABLE 7

While, in different parts of the experiment, the yield of the six thick rows varied considerably as did, also, the yield of the six thin rows, each thick row gave a larger yield than either of the two thin rows adjoining it, and no thin row outyielded any thick row in any part of the experiment. This is true for both weight and number of tubers in all three grades. In other words, the experiment consistently showed a larger yield for thick than for thin planting.

[1] On Row 2, two; on Row 6, two; and on Row 13, three tubers.

TABLE 7.— YIELD BY ROWS IN 1918 EXPERIMENT: NUMBER AND WEIGHT OF TUBERS.

Row*	Spacing in row	Tubers under 1 oz.			Tubers 1–2 oz.			Tubers over 2 oz.			Tubers of all grades		
		Number	Weight		Number	Weight		Number	Weight		Number	Weight	
	In.		Lbs.	Oz.		Lbs.	Oz.		Lbs.	Oz.		Lbs.	Oz.
1........	6	206	8	3	385	35	8	1,069	242	0	1,660	285	11
2........	15	110	4	0	133	13	3	740	203	11	983	220	14
3........	6	294	7	8	468	43	3	1,022	225	8	1,784	276	3
4........	15	73	2	8	145	13	3	656	170	4	874	185	15
5........	6	251	9	2	460	43	0	1,013	228	12	1,724	280	14
6........	15	101	3	5	128	12	2	742	195	2	971	210	9
7........	6	242	9	4	471	43	14	1,018	215	8	1,731	268	10
8........	15	94	3	9	159	15	4	767	200	8	1,020	219	5
9........	6	252	9	8	500	47	2	1,123	246	2	1,875	302	12
10........	15	133	4	7	184	16	8	821	212	2	1,138	233	1
11........	6	293	11	4	505	46	8	1,113	248	0	1,911	305	12
12........	15	88	2	6	187	22	8	703	192	8	978	217	6
AVERAGE..	6	256	9	2	465	43	3	1,060	234	5	1,781	286	10
	15	100	3	6	156	15	7	738	195	11	994	214	8

* Number of rows required to make an acre, 50.

MISSING HILLS

It has been stated that there was a stand of about 95 per cent. This is based on counts made on the thin rows. There were eight misses in Row 2, ten in Row 4, eleven in Row 6, eight in Row 8, nine in Row 10, and nineteen in Row 12.[1] In every instance these were single-hill skips. It appears that we have, in this case, means for making a fairly accurate comparison of what the yields on the thin rows would have been had there been no misses. In other words, we can correct the yield for full stand by using the formulas given on page 68 of Bulletin No. 459 of this Station.[2] Clearly, these formulas are applicable because the experiment furnishing the data from which they were derived was conducted on an adjoining plat of the same kind of soil, planted on the same day, with some of the

[1] Each row contained 232 hills and equalled one-fiftieth acre.

[2] These formulas are: (1) Corrected yield, $CY = \frac{\text{actual yield}}{\text{stand value}}$; and (2) stand value, $SV = 1 - \frac{m - 0.464s}{n}$, when m is the number of missing hills per acre, s the number of skips per acre, and n the number of hills per acre in a full stand.

same lot of seed, and with the same spacing (15 by 36 inches) as used in the 1918 spacing experiments.

Presumably, the percentage of a full stand on thick rows was practically the same as that on thin rows, but as it was difficult to determine the number of missing hills accurately, it was not attempted. Moreover, even if the number of misses were known there would be no means of correcting the yields for full stand because we have no formula applicable to six-inch planting.

Since it is impossible to correct the yields for full stand on both thick and thin planting we are obliged to use the actual yields for comparison. While this is obviously disadvantageous to the thin planting the writer inclines to the opinion that it is not unfair, because it is one of the merits of six-inch planting that it greatly lessens the risk of getting a low-yield stand thru failure of the seed-pieces to grow.

TABLE 8.— MEAN YIELDS PER ACRE IN 1918 EXPERIMENT: SUMMARY OF DATA IN TABLE 7.

SPACING IN ROW	TUBERS UNDER 1 OZ.		TUBERS 1–2 OZ.		TUBERS OVER 2 OZ.		TUBERS OF ALL GRADES	
	Number	Quantity	Number	Quantity	Number	Quantity	Number	Quantity
In.		*Bu.*		*Bu.*		*Bu.*		*Bu.*
6	12,817	7.6	23,242	36.0	52,983	195.2	89,042	238.8
15	4,992	2.8	7,800	12.9	36,908	163.0	49,700	178.7

DISCUSSION OF TABLE 8

As in 1915 and 1917, thick planting gave a considerably larger yield in all three grades of tubers. In the marketable grade the difference amounted to 16,075 tubers or 32.2 bushels per acre. The average weight of the tubers of the marketable grade was somewhat greater than in either 1915 or 1917, being 3.54 ounces for thick planting and 4.28 ounces for thin planting. Again, the tubers from thin planting were of better average size for table use.

THE EXPERIMENT OF 1919

The experiment in 1919 consisted of twenty-four rows 125 feet long and three feet apart. Twelve thick-planted rows alternated with twelve thin-planted rows. Each thick-planted row contained 250 plants six inches apart; each thin-planted row, 100 plants fifteen inches apart. The number of rows required to make an acre was 116.16. The total area occupied by the experiment was a little over one-fifth acre.

The soil was a heavy clay loam, fairly uniform, and of medium fertility. No manure or fertilizer was used on the experiment plat either in 1918 or 1919. The plat had been used as a kitchen garden in 1918. The surface drainage was good except at one end of the plat where a few plants were slightly injured by standing water after a heavy shower.

The plat was plowed crosswise to the direction in which the rows were to run. On the surface, the soil was thoroly worked and made fine and free from lumps, but on account of heavy rains previous to plowing it was impossible to fit it as deeply as good potato culture requires so that it was necessary to resort to rather shallow planting. Shallow furrows were made with a double mold-board plow, the seed-pieces placed by hand and accurately spaced by means of a ruled rod, and the seed covered by means of hoes.

The seed was of the variety Enormous No. 9, and was treated with formaldehyde for scab on May 14, cut on May 27, and planted June 5. The seed-pieces were cut with considerable care in order to obtain at least one good eye to each piece and to make them fairly uniform in size. After cutting, the entire lot was placed in a pile and thoroly mixed and the seed-pieces then counted and weighed. The average weight was found to be 1.41 ounces. The thin planting required 17 bushels of seed per acre and the thick planting 42.5 bushels.

The soil being dry and the weather hot at time of planting, some of the seed-pieces failed to produce plants. An examination made on July 5, when a majority of the plants were about six inches high, showed thirty-four misses on the twelve thin-planted rows or about 97 per cent of a full stand. In addition, there were a few plants which were barely up and were evidently weaklings. The places of the missing plants were promptly filled by

transplanting into them potato plants of the same age and variety. In this way a full stand was obtained on the thin-planted rows. Nothing was done about filling blanks in the thick-planted rows. Presumably, the percentage of missing plants in these rows was about the same as in the thin-planted rows, but it was not practicable to replace them. While this method of procedure introduced an element of inequality between the thick and thin rows, giving a slight advantage to the thin planting, it was deemed expedient.

The plants were thoroly sprayed with bordeaux mixture four times. In the first two sprayings arsenate of lead was added for the control of insects. No damage was done by Colorado potato beetles or by blight and there was no rot affecting the tubers. Flea beetles caused slight injury and many plants were also slightly injured by the tarnished plant bug. After about the first of August there was considerable rolling and curling of the leaves and during September a little tipburn due, apparently, to leafhoppers and dry weather. There was practically no true leaf roll.

During the greater part of the summer of 1919 the weather was too dry for a vigorous growth of potato plants and, in addition, the soil was not rich. Between the rows there was much exposed ground which became hard and dry, altho it can scarcely be said that the plants suffered much from drought. The plants were fairly uniform in size over the whole plat and died naturally and evenly during the last week of September.

The grading, counting, and weighing of the crop were all done by the writer and much care was taken to avoid errors. The yield by rows is shown in Table 9.

DISCUSSION OF TABLE 9

Let us first consider the figures in the last two columns which show the number and weight of tubers of all grades produced by each row. Each thick row produced a considerably larger number and weight of tubers than either of the two thin rows adjoining it. In fact, no thin row outyielded any thick row.

As regards total weight of tubers, the least difference between the yield of a thick row and that of a thin row adjoining it is 11 pounds 13 ounces, which is at the rate of 22.9 bushels per acre. (Compare Rows 10 and 11.) The greatest difference between

the yield of a thick row and that of a thin row adjoining it is 50 pounds 10 ounces, or 98 bushels per acre. (Compare Rows 15 and 16.)

As regards total number of tubers, the least difference between thick and thin rows adjoining each other is 279, or 32,409 per acre. (Compare Rows 5 and 6.) The greatest difference is 343, or 39,843 per acre. (Compare Rows 9 and 10.)

TABLE 9.— YIELD BY ROWS IN 1919 EXPERIMENT: NUMBER AND WEIGHT OF TUBERS.

Row *	Spacing in row	Tubers under 1 oz.			Tubers 1–2 oz.			Tubers 2–12 oz.		Tubers over 12 oz.			Tubers of all grades		
		No.	Weight		No.	Weight		No.	Weight	No.	Weight		No.	Weight	
	In.		Lbs.	Oz.		Lbs.	Oz.		Lbs.		Lbs.	Oz.		Lbs.	Oz.
1.......	15	30	1	3	36	3	5	313	114.5	7	6	9	386	125	9
2.......	6	66	2	4	82	7	13	514	144.0	8	7	4	670	161	5
3.......	15	32	1	1	35	2	14	295	108.0	17	17	8	379	129	7
4.......	6	81	2	7	100	9	12	522	151.0	5	4	4	708	167	7
5.......	15	47	1	8	45	4	3	331	110.5	8	7	8	431	123	11
6.......	6	97	3	6	128	12	8	483	132.0	2	1	13	710	149	11
7.......	15	39	1	4	42	3	12	307	104.5	14	15	0	402	124	8
8.......	6	98	3	3	104	9	8	498	134.0	0	0	0	700	146	11
9.......	15	38	1	1	30	2	9	319	107.5	9	7	10	396	118	12
10.......	6	98	2	10	122	12	0	517	129.5	2	1	12	739	145	14
11.......	15	41	1	10	41	3	14	326	117.5	12	11	3	420	134	3
12.......	6	96	3	7	136	14	0	491	135.5	0	0	0	723	152	15
13.......	15	41	1	12	49	4	13	344	113.0	11	9	13	445	129	6
14.......	6	102	3	9	150	14	0	476	135.0	2	1	15	730	154	8
15.......	15	49	1	12	35	3	5	303	100.0	7	5	15	394	111	0
16.......	6	98	3	4	120	11	8	513	146.0	1	0	14	732	161	10
17.......	15	38	1	6	48	4	8	296	103.0	7	6	0	389	114	14
18.......	6	89	2	12	127	11	13	502	129.5	2	1	10	720	145	11
19.......	15	41	1	8	42	4	4	280	96.0	6	5	8	369	107	4
20.......	6	90	3	1	107	10	8	467	128.0	2	1	10	666	143	3
21.......	15	20	0	9	63	5	11	288	97.0	9	8	7	380	111	11
22.......	6	67	2	6	137	13	0	475	129.5	4	3	15	683	148	13
23.......	15	37	1	8	44	4	1	289	104.0	15	13	6	385	122	15
24.......	6	76	2	12	103	10	0	489	136.0	6	5	3	674	153	15
Average	15	38	1	5	42	3	15	308	106.3	10	9	9	398	121	2
	6	88	2	15	118	11	6	496	135.8	3	2	8	705	152	10

* Number of rows required to make an acre, 116.16.

It is interesting to note that the difference in weight varies much more widely than the difference in number of tubers, also, that the pairs of rows showing the least and the greatest difference in weight of tubers are not the same as those showing the least and the greatest difference in number of tubers.

Since the variation, in different parts of the experiment plat, in the difference between the yield of thick and thin rows adjoining each other must be due, in large part, to differences in soil conditions, it appears that the soil influences the size of the tubers more than it does the number of the tubers.

Now, turning our attention to the yield of tubers in the four grades, we find that for each of the three smaller grades of tubers each thick row gave a considerably larger number and greater weight of tubers than either of the two thin rows adjoining it; also, that no thin row outyielded any thick row either in number or in weight of tubers belonging to any one of the three smaller grades. But in the grade containing extra large tubers (over twelve ounces in weight) the opposite condition existed, namely, it was the thin rows (with one exception) which produced the larger number and weight of tubers. The exception noted is the thin row (No. 1) which yielded only seven extra large tubers while the adjoining thick row (No. 2) yielded eight.

The above comparison of the differences in yield of thick and thin rows adjoining each other shows the results to have been highly consistent thruout the experiment. This indicates that the differences in yield obtained in the experiment are actually due to differences in thickness of planting rather than to inequalities in soil or treatment.

In Table 10 the data shown in Table 9 are summarized and given in terms of "yield per acre" which makes them more intelligible.

TABLE 10.— MEAN YIELDS PER ACRE IN 1919 EXPERIMENT: SUMMARY OF DATA IN TABLE 9.

SPACING IN ROW	TUBERS UNDER 1 OZ.		TUBERS 1-2 OZ.		TUBERS 2-12 OZ.		TUBERS OVER 12 OZ.		TUBERS OF ALL GRADES	
	Number	Quantity	Number	Quantity	Number	Quantity	Number	Quantity	Number	Quantity
In.		*Bu.*		*Bu.*		*Bu.*		*Bu.*		*Bu.*
6	10,241	5.7	13,707	22.0	57,567	263.0	329	4.9	81,844	295.6
15	4,385	2.6	4,937	7.6	35,729	205.8	1181	18.5	46,232	234.5

DISCUSSION OF TABLE 10

In the three smaller grades of potatoes the yield from thick planting was considerably greater than that from thin planting as in all previous experiments; but this year, for the first time since 1914, we have to take into account the fourth grade containing tubers over twelve ounces in weight. Altho the yield of tubers of this grade was not large there were 13.6 bushels per acre more of them with

thin planting than with thick planting. If these extra large tubers are counted as marketable the difference in yield of marketable tubers (all over two ounces) was 20,986 or 43.6 bushels per acre in favor of thick planting. On the other hand, if only tubers weighing between two and twelve ounces are counted as marketable, the difference was 21,838 tubers or 57.2 bushels per acre.

As regards their desirability for table use, the tubers over two ounces in weight from thick planting were clearly superior to those from thin planting even if the extra large tubers were left out of consideration. The average weight of the tubers in the two-to-twelve-ounce grade was 4.39 ounces for thick planting and 5.53 ounces for thin planting.

GENERAL DISCUSSION OF RESULTS

The data presented in Tables 1 to 10 may be used in various ways to answer a large number of questions most of which, however, may be classified under one of four heads, *viz.:* (1) Number of tubers; (2) quantity of tubers; (3) size of tubers; and (4) net difference in yield. In Tables 11 to 16 the data have been brought together in such a way as to facilitate a comparison of the principal results obtained in different seasons.

NUMBER OF TUBERS

Table 11 shows the number of tubers of each grade per acre produced by the two kinds of planting in each of the five seasons during which the experiments were conducted. It will be observed that in each of the three smaller grades of tubers the yield from thick planting was considerably larger than that from thin planting in every year. The same is true of the total yield, given in the last column. But the yield of extra large tubers, when there were any, was greatest on the thin planting. Roughly speaking, thick planting produced, on the average, somewhat more than twice as many tubers under two ounces in weight as did thin planting; while, of tubers over two ounces in weight, the yield from thick planting was not quite one and one-half times that from thin planting; and the average total number of tubers from thick planting was about one and two-thirds times that from thin planting.

Another, and better, way of stating the results is by means of percentages as in Table 13. Here, the percentage of increase due to

thick planting is given for each year and averaged for five years. In the smallest grade, the average increase was 119.1 per cent; in the one-to-two-ounce grade, 144.5 per cent; in the over-two-ounce grade, 44.3 per cent; and for total yield (tubers of all grades) 67.2 per cent.

TABLE 11.—NUMBER OF TUBERS PER ACRE, 1914-1919.

YEAR	SPACING	TUBERS UNDER 1 OZ.	TUBERS 1-2 OZ.	TUBERS 2-12 OZ.	TUBERS OVER 12 OZ.	TUBERS OF ALL GRADES
	In.					
1914	6	10,974	13,635	72,598	633	97,840
	15	5,371	5,910	48,175	3,500	62,956
1915	6	14,020	25,920	71,230	None	111,170
	15	6,300	13,120	49,480	None	68,900
1917	6	10,608	32,878	44,880	None	88,366
	15	5,950	15,028	33,150	None	54,128
1918	6	12,817	23,242	52,983	None	89,042
	15	4,992	7,800	36,850	58	49,700
1919	6	10,241	13,707	57,567	329	81,844
	15	4,385	4,937	35,729	1,181	46,232
AVERAGE	6	11,732	21,876	59,852	192	93,652
	15	5,400	9,359	40,677	948	56,383

In four of the five experiments the percentage of increase was considerably greater in the one-to-two-ounce grade than in the under-one-ounce grade; but in the experiment of 1915 this rule was reversed, owing probably, to the shortness of the growing season that year.

The fourth column of Table 14 shows the average number of tubers produced per plant by the two kinds of planting for each of the five years. The figures here given were obtained by dividing the total number of tubers per acre by the number of plants per acre which is 29,040 for thick planting and 11,616 for thin planting. The largest number of tubers per plant, for both kinds of planting, was obtained

in 1915 when there was an abundance of rain during the setting season, while the least number was obtained in 1919 when the weather was dry at setting time. The reduction in average number of tubers per plant due to thick planting varied from 28.3 per cent in 1918 to 37.8 per cent in 1914.

QUANTITY OF TUBERS

The quantity of tubers of each grade per acre produced by the two kinds of planting in each year is shown in Table 12.

The largest total yields, obtained in 1914, were twice the size of the smallest total yields, obtained in 1917; yet the difference in

TABLE 12.— QUANTITY OF TUBERS PER ACRE, 1914–1919.

YEAR	SPACING	TUBERS UNDER 1 OZ.	TUBERS 1–2 OZ.	TUBERS 2–12 OZ.	TUBERS OVER 12 OZ.	TUBERS OF ALL GRADES
	In.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
1914	6	*?	*?	354.9	9.3	392.7
	15	†?	†?	280.2	51.4	343.4
1915	6	9.2	39.6	260.4	None	309.2
	15	3.7	20.0	202.2	None	226.0
1917	6	6.4	48.7	143.0	None	198.1
	15	3.5	22.1	122.4	None	148.0
1918	6	7.6	36.0	195.2	None	238.8
	15	2.8	12.9	162.2	0.8	178.7
1919	6	5.7	22.0	263.0	4.9	295.6
	15	2.6	7.6	205.8	18.5	234.5

* Yield of tubers under two ounces in weight, 28.5 bushels per acre.
† Yield of tubers under two ounces in weight, 11.8 bushels per acre.

the yields of thick and thin planting for these two years was practically the same and the smallest of the series, namely, 49.3 bushels per acre in 1914, and 50.2 bushels per acre in 1917. In this connection, it should be noted that the experiments of 1914 and 1917 were the poorest of the series as has been explained elsewhere.

The experiments of 1918 and 1919, altho showing quite different total yields, gave practically the same difference in favor of thick planting, namely, 60.1 bushels per acre in 1918, and 61 bushels per acre in 1919.

The best showing made by thick planting was in the experiment of 1915 when the difference in total yield was 83.2 bushels per acre. It will be remembered that this was the year in which the plants were killed early by blight.

If the experiments are ranked according to the percentage of increase in total quantity of tubers resulting from thick planting, their order, from the lowest to the highest, would be as follows: 1914, 1919, 1918, 1917, and 1915. The average percentage of increase was 28.9. (See Table 13.)

Comparing the percentage of increase in number of tubers with the percentage of increase in quantity of tubers, as shown in Table 13,

TABLE 13.— PERCENTAGE OF INCREASE IN NUMBER AND WEIGHT OF TUBERS PER ACRE DUE TO THICK PLANTING, 1914–1919.

YEAR	PERCENTAGE OF INCREASE RESULTING FROM THICK PLANTING*							
	TUBERS UNDER 1 OZ.		TUBERS 1–2 OZ.		TUBERS OVER 2 OZ.		TUBERS OF ALL GRADES	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
1914	104.3	†	130.7	†	41.7	9.8	55.4	14.4
1915	122.5	148.6	97.6	98.0	44.0	28.8	61.3	36.8
1917	78.3	82.9	118.8	120.4	35.4	16.8	63.3	33.9
1918	156.8	171.4	198.0	179.1	43.6	19.8	79.2	33.6
1919	133.5	119.2	177.6	189.5	56.9	19.4	77.0	26.0
AVERAGE	119.1	......	144.5	......	44.3	18.9	67.2	28.9

* Computed by dividing the difference in yield of thick and thin planting by the yield of thin planting.

† Data lacking.

the latter is usually the higher in the two smaller grades of tubers, but considerably the lower in the marketable grade and in the total yield.

For a study of the average quantity of tubers produced per plant see Table 14, sixth column. It will be seen that in 1914 the average

yield per plant on thick rows was less than half that on thin rows, but in each of the other four years it was a little over half.

TABLE 14.—NUMBER, QUANTITY, AND AVERAGE WEIGHT OF TUBERS, 1914–1919.

Year	Spacing in row	Number of tubers of all grades		Quantity of tubers of all grades		Average weight of tubers	
		Per acre*	Per plant	Per acre*	Per plant	Over 2 oz.	All grades
	In.			*Bu.*	*Oz.*	*Oz.*	*Oz.*
1914	6	97,840	3.37	392.7	13.0	4.75	3.86
	15	62,956	5.42	343.4	28.4	6.16	5.24
1915	6	111,170	3.83	309.2	10.2	3.51	2.67
	15	68,900	5.93	226.0	18.7	3.92	3.15
1917	6	88,366	3.04	198.2	6.6	3.06	2.17
	15	54,128	4.66	148.0	12.2	3.55	2.62
1918	6	89,042	3.07	238.8	7.8	3.54	2.54
	15	49,700	4.28	178.7	14.8	4.28	3.45
1919	6	81,844	2.82	295.5	9.8	4.44	3.47
	15	46,232	3.98	234.5	19.4	5.66	4.87

* There are 29,040 plants on an acre of potatoes planted 6 by 36 inches, and 11,616 on an acre planted 15 by 36 inches.

SIZE OF TUBERS

It is clear that the reduction in the average size of the tubers, which is the inevitable result of thick planting, improves the quality of the crop for seed purposes, but its effect on the quality of the crop for table use depends upon circumstances and is difficult to determine. For mixed lots of tubers it is very difficult to determine what average weight is most desirable. In fact, it is largely a matter of opinion. The writer's opinion, based upon observations made in connection with these experiments, is that a lot of tubers varying from two to twelve ounces in weight should have an average weight of about 4.25 ounces to be most desirable for general family use

where some of the tubers are to be used for boiling, some for baking, and some for mashed potatoes.[1]

Having this standard in mind, the figures in the next to the last column of Table 14 enable us to form an opinion as to the relative desirability of the crops from thick and thin planting. Apparently, the crop from thin planting was superior to that from thick planting in 1915, 1917, and 1918, since, in the former, the average size of the tubers over two ounces in weight was nearer the standard. In 1915 and 1917 there were no tubers over twelve ounces in weight, and in 1918 only a few, all of which were from thin planting.

In 1914 and 1919 even the tubers from thick planting were of too large size, but were better than those from thin planting. The average weights given in Table 14 are for all tubers over two ounces in weight, but even if restricted to tubers between two and twelve ounces all of the averages for 1914 and 1919 would still be above the standard of 4.25 ounces.

Of the total number of tubers produced, the percentage which attained a weight of two ounces or more was, on the average, about one-eighth less for thick planting than for thin planting, being 64.1 per cent for the former and 73.8 per cent for the latter.[2] The

---

[1] Whipple (Mont. Agr. Exp. Sta. Bul. 106, 5-6, 1915) in discussing the results of some thinning experiments with potatoes, says: "The quality of the marketable crop was greatly improved by thinning. * * * * Rural planted 14 inches apart and thinned produced marketable tubers averaging 7.4 ounces, while in unthinned rows the marketable tubers averaged 6 ounces in weight. Russet Burbank planted 12 inches apart and thinned produced marketable tubers with an average weight of 7.5 ounces, and unthinned rows, marketable tubers averaging 5.3 ounces."

These potatoes were graded over a 1¾-inch mesh screen which would permit the passage of tubers weighing somewhat more than two ounces. Nothing is said concerning the weight of the larger tubers. Evidently, this author's standard for size of tubers is very different from our own.

[2] Emerson (Nebr. Agr. Exp. Sta. Bul. 97, 9, 1907) in discussing the results of some experiments which he conducted in Nebraska, says: "These tests indicate that the per cent of small tubers in the crop depends more upon the size of the seed-pieces (quantity of seed per hill) than upon the distance between hills or the quantity of seed per acre. The per cent of small tubers increased with the size of the seed-piece, being greatest where large seed pieces were used and least where small ones were planted."

In our own experiments seed-pieces of different sizes were used in different seasons yet the percentage of small tubers was constantly over 9.6 per cent higher on thick planting than on thin. This appears to disagree with the conclusion drawn by Emerson. However, the results of the two experiments do not admit of close comparison. The "small" tubers in Emerson's experiments were tubers under three ounces in weight, as compared with tubers under two ounces in weight in our experiments. Also, there were other important differences.

percentages for each of the five experiments are given in Table 15. The lowest percentages were obtained in 1917 in conjunction with the lowest yields in quantity (tho not in number) of tubers, and the highest percentages were obtained in 1914 in conjunction with the highest yields in quantity (tho not in number) of tubers. The greatest difference between the percentages for thick and thin planting and, also, the greatest reduction resulting from thick planting, occurred in 1918.

TABLE 15.—PERCENTAGE OF TOTAL NUMBER OF TUBERS WHICH ATTAINED A WEIGHT OF TWO OUNCES OR MORE, 1914–1919.

SPACING	1914	1915	1917	1918	1919	AVERAGE
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
6-inch......	74.8	64.7	50.8	59.5	70.7	64.1
15-inch......	82.8	71.8	61.2	74.3	79.8	73.9

DIFFERENCE IN NET YIELD

Six-inch planting requires two and one-half times the quantity of seed necessary for fifteen-inch planting. This fact must be given consideration when the yields are compared for the purpose of determining which is the better method of planting to employ. It is necessary not only to deduct the extra quantity of seed used in thick planting before making a comparison of yields, but, also, to make allowance for the difference in the value of potatoes in the spring and in the fall.

The first of these two corrections is easily made, but the second can be estimated only, and for this reason it has been left out of account in the compilation of Table 16. In this table "net difference" means the difference in yield after deducting the seed. Also, no account is taken of tubers under one ounce in weight since tubers of this size are almost valueless.

The average net difference in favor of thick planting was 34.7 bushels per acre. Somewhat more than one half of this difference (18.7 bushels) consisted of tubers weighing over two ounces each, and the remainder of tubers between one and two ounces in weight.

The greatest net difference (46.6 bushels) occurred in the 1915 experiment, the outstanding features of which were: (1) Large seed-pieces; (2) an unusually heavy setting of tubers; and (3) a short, but favorable growing season.

The least net difference (24.9 bushels) occurred in the 1914 experiment which was characterized by a long, favorable growing season, a high yield, and many overgrown tubers.

TABLE 16.— DIFFERENCE IN YIELD AFTER DEDUCTING SEED, 1914-1919.

YEAR	CHARACTER OF SEED	AVERAGE WEIGHT OF SEED-PIECES	QUANTITY OF SEED PER ACRE		NET DIFFERENCE PER ACRE IN FAVOR OF THICK PLANTING *	
			Thick planting	Thin planting	Tubers 1-2 oz.	Tubers over 2 oz.
		Oz.	*Bu.*	*Bu.*	*Bu.*	*Bu.*
1914...	Pieces of large tubers	1.029	31.1	12.4	†11.0	13.9
1915...	Pieces of large tubers	1.721	52.0	20.8	19.6	27.0
1917...	Whole small tubers	0.813	24.5	9.8	11.9	20.6
1918...	Pieces of large tubers	0.955	28.8	11.5	23.1	14.1
1919...	Pieces of large tubers	1.410	42.5	17.0	14.4	18.1

* Disregarding tubers weighing less than one ounce.

† The estimated quantity of 7,725 tubers. Separate weights of the two smaller grades of tubers were not taken in 1914. The difference in yield of tubers under two ounces in weight was 16.7 bushels per acre, made up of 7,725 tubers between one and two ounces, and 5,603 tubers under one ounce in weight.

CONCLUSIONS

Notwithstanding the fact that a considerable number of interesting and suggestive data were obtained in these experiments, it is impossible to draw definite conclusions from them as to the relative number, quantity, or size of tubers which may be expected from six-inch and fifteen-inch planting. Several factors entering into the problem have received little or no consideration, and it is not known how they might affect the results. However, if the results obtained

are dependable,[1] the following general conclusions seem to be warranted:

In the production of seed potatoes of varieties of the Rural group, New York growers may well consider planting considerably closer than 15 by 36 inches since, thereby, the net quantity of the crop is likely to be increased and its quality improved, particularly on rich soil.

If the seed potatoes are designed for home use the spacing in the row may be as close as is consistent with roguing. (Probably it is impracticable to rogue properly, plants as close as six inches.)

If the crop is to be sold (either for seed or for table use) the difficulty of disposing of the small tubers may necessitate somewhat thinner planting, except on rich soil. Potatoes grown on rich garden soil for table use may be planted as close as 6 by 30 inches with advantage.

---

[1] With the writer, the method of alternation or replication of single-row plats used in these experiments has been a favorite one for several kinds of potato experiments, because it eliminates the inequality of soil which is a very important source of error in field experiments.

Recently, Kiesselbach (Nebr. Agr. Exp. Sta. Research Bul. 13, 1918) has shown that, in rate-of-planting tests with oats, wheat, and corn, the method of alternating single-row plats does not give reliable results. Thru what he calls "plat competition" the thick-planted rows have an advantage which makes their yield higher than normal and that of the thin-planted rows lower than normal.

Whether this is true also of potato experiments is not known. Probably, it holds for some conditions and not for others. If the rows are close together and the potato plants large the plants in one row must compete, to some extent, with plants in adjacent rows. It may have occurred in our experiments of 1914 and 1915, particularly in the garden experiment of 1914, in which the rows were only thirty inches apart. In the experiments of 1917, 1918, and 1919, in which the rows were 36 inches apart and the plants of medium size, it seems improbable that the plants in one row were much influenced by those in adjacent rows.

THE NEW YORK SEED LAW AND SEED TESTING*

M. T. MUNN

THE NEW YORK SEED LAW

Farm seeds, the most variable, and, weight for weight, the most expensive material the farmer has to buy, can be purchased on and after July 1, 1920, with a complete tag or label attached to each sack, bag, or container showing the purity, germination, amount of weed seeds present, and the presence or absence of certain noxious weed seeds.

After considerable agitation New York has finally secured a law designed to protect the purchaser of seeds by giving him full information regarding the quality of the contemplated purchase; and, also, to protect the honest, legitimate dealer or seedsman against the practices of dishonest and irresponsible ones.

The New York seed law, which became effective July 1, 1920, is primarily a labeling law in contradistinction to a grading law when grades are required. A copy of the law may be had upon application to the Commissioner of Agriculture, Albany, N. Y.

THE MAIN FEATURE OF THE LAW

The law requires the labeling of all agricultural seeds which are sold, offered, or exposed for sale, within the State of New York, for seeding purposes within the State either in bulk, packages, bags, or other containers of 10 pounds or more with the exception of special mixtures, such as lawn mixtures, when 8 ounces is the minimum limit of weight.

KINDS OF SEEDS TO BE LABELED

The term "agricultural seeds," as defined in the law, includes practically every kind of seed planted upon New York farms. The following are designated as agricultural seeds and are subject to

* Reprint of Bulletin No. 476, June, 1920.

all the provisions of the seed law when sold for seeding purposes: Canada bluegrass, Kentucky bluegrass, orchard grass, redtop, timothy, brome grass, fescues, millets, tall meadow oat grass, Italian rye grass, kafir corn, perennial rye grass, sorghum, sudan grass, and other grasses; alfalfa, alsike clover, crimson clover, red clover, white clover, sweet clover, vetches, rape, and flax; and buckwheat, barley, corn, oats, rye, wheat, and other cereals.

SEED MIXTURES

All mixtures of alsike clover and timothy, alsike and white clover, redtop and timothy, and alsike and red clover in lots of 10 pounds or more must be fully and completely labeled in the same manner as unmixed agricultural seeds.

Special mixtures of agricultural seeds, that is, mixtures which usually carry a number of different kinds of seeds, when in lots of 8 ounces or more must also be fully labeled except that the law does not require a statement of the germination percentage in the case of the special mixtures. However, the percentage of inert matter must be given.

In the case of both mixtures and special mixtures as defined above the law requires a statement to the effect that "such seed is a mixture;" and also, "the name and approximate percentage by weight of each kind of agricultural seed present" in excess of 5 per cent or more of the total mixture.

THE LABEL

The law requires each lot of seed to carry a statement, tag, or label giving the following information:

1. **The commonly accepted name of such seed.**— For example, Dwarf Essex rape, Canada bluegrass, and Kentucky bluegrass must be called such on the label since these are their commonly accepted names, and not simply rape or bluegrass. The kind of seed must, therefore, be indicated. Variety and sub-variety names are not required, but if named on the label, as the vendor may elect, they must be the true variety name, otherwise, the seed would be misbranded or falsely labeled. As an illustration, if a label reads "yellow sweet clover" the seed must be of that variety and not of another variety such as white sweet clover.

2. **The approximate percentage, by weight, of purity.**— A statement of purity shows the amount of crop seeds of the kind which the label indicates as compared with the amount of weed seeds and inert matter present and must be expressed in terms of percentage by weight. Purity, then, is one of the important factors which determines quality and consequently price.

3. **The percentage of weed seeds.**— The total amount of weed seeds, whether noxious, troublesome, or otherwise, expressed in terms of percentage, must be stated on the tag or label. The term "weed seeds" as defined in the law does not include the seeds of field crops which are listed in the law as "agricultural seeds." Seeds of crop plants of agricultural value, which occur incidentally or thru natural infestation by ripening at the same time and being harvested with the crop and which occur in any sample of a given kind of seed, are known to seed analysts and the seed trade as "other crop seeds," "foreign seeds," "seeds of extraneous crop plants," and "other crop seeds of agricultural value." A distinction should be clearly made, therefore, between the accidental commercial seeds and weed seeds in a sample. The seed law does not require that the percentage of "other crop seeds" or of accidental commercial seeds be stated, nevertheless, it should be clearly understood that seed testing stations and laboratories in making purity tests of a lot of seed, do not, as a rule, separate and express in separate percentages the accidental commercial seeds and the weed seeds. It is often of great importance that the percentages of other crop seeds be given in distinction from weed seeds since, in many cases, they are of equal or greater value than the agricultural seed in which they occur.

4. **The name of each kind of the seeds of noxious weeds.**— The name of each kind of noxious weed present must be stated on the label when it occurs, either singly or collectively, in excess of 1 seed in each 5 grams (about one-sixth of an ounce) of small seeds such as timothy, clover, and alfalfa; of 1 seed in each 25 grams (about six-sevenths of an ounce) of millet, rape, and seeds of like size; and of 1 seed in each 100 grams (about 3½ ounces) of oats, wheat, vetch, and seeds of like size. The law designates four kinds of weeds as noxious in this State, *viz.* quack grass, wild mustards, Canada thistle, and dodders.

The sale of seeds containing these noxious weed seeds is not prohibited, but it is required that the label or tag show if they

are present, in order that the purchaser may avoid buying seeds containing them.

5. **The percentage of germination together with the month and year when the test was made.**— With respect to germination, the law requires that two very important facts be stated on the tag or label on all lots of seeds except "special mixtures." First, the percentage of germination or the percentage of seeds which are alive or viable and which will sprout or germinate within the normal number of days must be indicated. This is highly essential in determining the quality and actual value of the seed for seeding purposes since dead seed is worthless for planting and is deceptive in determining the amount of seed to use. Second, the date, that is, the month and year, when the test was made must be given. This second item is essential since the vitality of seeds decreases with age, and the purchaser can readily determine from the tag or label whether sufficient time has elapsed to materially affect the viability of the seed under normal storage conditions.

6. **The full name and address of the vendor.**— The label must also give the full name and address of the person who sells, offers, or exposes for sale such seeds.

LABELING MIXTURES

Mixtures of alsike clover and timothy, alsike and white clover, redtop and timothy, and alsike and red clover, when in lots of 10 pounds or more, must carry a tag or label giving essentially the same information required for the unmixed or regular run of agricultural seeds except that the tag must state that such seed is a mixture, and must also give the approximate percentage by weight of each kind of crop seed present in excess of 5 per cent of the total mixture. Also, each kind of the above-defined noxious weed seeds present in excess of 1 in each 15 grams of the mixture must be named.

LABELING SPECIAL MIXTURES

Special mixtures of seeds, such as golf, pasture, meadow, and lawn mixtures when sold, offered, or exposed for sale as mixtures, in packages or other containers of 8 ounces or more, must carry for each lot a tag or label stating (1) that such seed is a mixture,

(2) the name of each kind of "agricultural seed" present in the proportion of 5 per cent or more of the total mixture, (3) the total percentage of weed seeds, (4) the percentage by weight of inert matter such as chaff, sticks, broken stems, sand, etc., (5) the name of each kind of noxious weed, as defined on page 313, present in excess of 1 seed in each 15 grams of the mixture, and (6) the full name and address of the vendor of such mixture.

FORM AND POSITION OF LABEL

The law does not require any particular form of statement, tag, or label except that it must convey definite information plainly written or printed in the English language as set forth therein, and must be placed on the exterior of the container. If the container is a bag of seed, the label should appear on the outside of the bag; if it is a barrel, bin, box, or package, on the outside of the container. The intent of the law is to place the information given on the label concerning the quality of the seed in such a form and position that it is accessible to the purchaser so that he may determine at a glance, if he will, what the seed is and, therefore, buy on his own responsibility.

The tag or label used may be made at home or purchased. It may be a common shipping tag such as seedsmen already have on hand, upon which the required information (the seed law items) is written, printed, or rubber stamped on one side and the address of the seedsman and the consignee placed on the reverse side. It may be a piece of cardboard or heavy paper, providing it is suitable for receiving and displaying the written or printed information plainly; or, in case of a box, the information may be stenciled or printed on the front side or on the outside of the cover. Current commercial customs of seedsmen have established a style or type of shipping tag which is being used on most of the farm seeds sold under the requirements of existing seed laws.

The following tags are suggested as suitable forms to use for labeling the three distinct classes of seeds provided for in the seed law, namely: (1) the general run of unmixed agricultural seed, (2) mixtures of two kinds of seeds, and (3) special mixtures of agricultural seeds which usually contain two or more kinds. The

information provided for on these tags is the minimum required by the seed law, for the three classes of seeds in order that they may be legally placed on sale or sold. The vendor or seller may add such other information as he may choose to be responsible for.

Common name..
Purity..per cent
Weed seeds..per cent
Noxious weeds..
....
In excess of 1 seed in specified amounts
Germination..per cent
Date of test..
Name..
Address..

FIG. 16.— A FORM OF TAG RECOMMENDED FOR LABELING UNMIXED AGRICULTURAL SEEDS AS PER SECTION 341 OF THE LAW.

Mixture
Common name..
..............................%..............................%
Weed seeds..per cent
Noxious weeds..
....
In excess of 1 seed in each 15 grams
Germination..............................%..............................%
Date of test..
Name..
Address..

FIG. 17.— A FORM OF TAG RECOMMENDED FOR LABELING MIXTURES OF TWO KINDS OF AGRICULTURAL SEEDS AS PER SECTION 342 OF THE LAW.

Special Seed Mixture
Common name .... %
.... % .... %
.... % .... %
Inert matter .... per cent
O Weed seeds .... per cent
Noxious weed seeds ....
....
In excess of 1 seed in each 15 grams
Name ....
Address ....

FIG. 18.—A FORM OF TAG RECOMMENDED FOR LABELING SPECIAL MIXTURES OF AGRICULTURAL SEEDS AS PER SECTION 343 OF THE LAW.

A careful comparison of the tags illustrated in Figs. 16, 17, and 18 will show that they differ. This is necessarily so since the label requirements for unmixed seed are quite different from those for mixtures or special mixtures. If the seller of seeds desires a general tag or label for universal use on all three classes of seeds sold and one which will comply substantially with all the label requirements of the seed law, the form shown in Fig. 19 may be suggested.

The advantage of the tag shown in Fig. 19 lies in the fact that this one style of tag can be used for all classes of farm seeds, thereby eliminating the necessity of preparing three different styles for the different classes. It must be borne in mind, however, that not all the label information contained or provided for on this tag is required for any one of the three particular classes of seeds designated in the text of the seed law. Nevertheless, in many cases where complete tests of seeds are made, as they should and must be, it may be less trouble to supply all of the data secured as a result of the test, rather than to keep in mind what may be omitted in order to have that particular class of seed properly and legally labeled. The blank space provided below the common name is to be used for the names and percentages of seeds used in compounding mixtures where such constitute 5 per cent or more by weight of the total mixture.

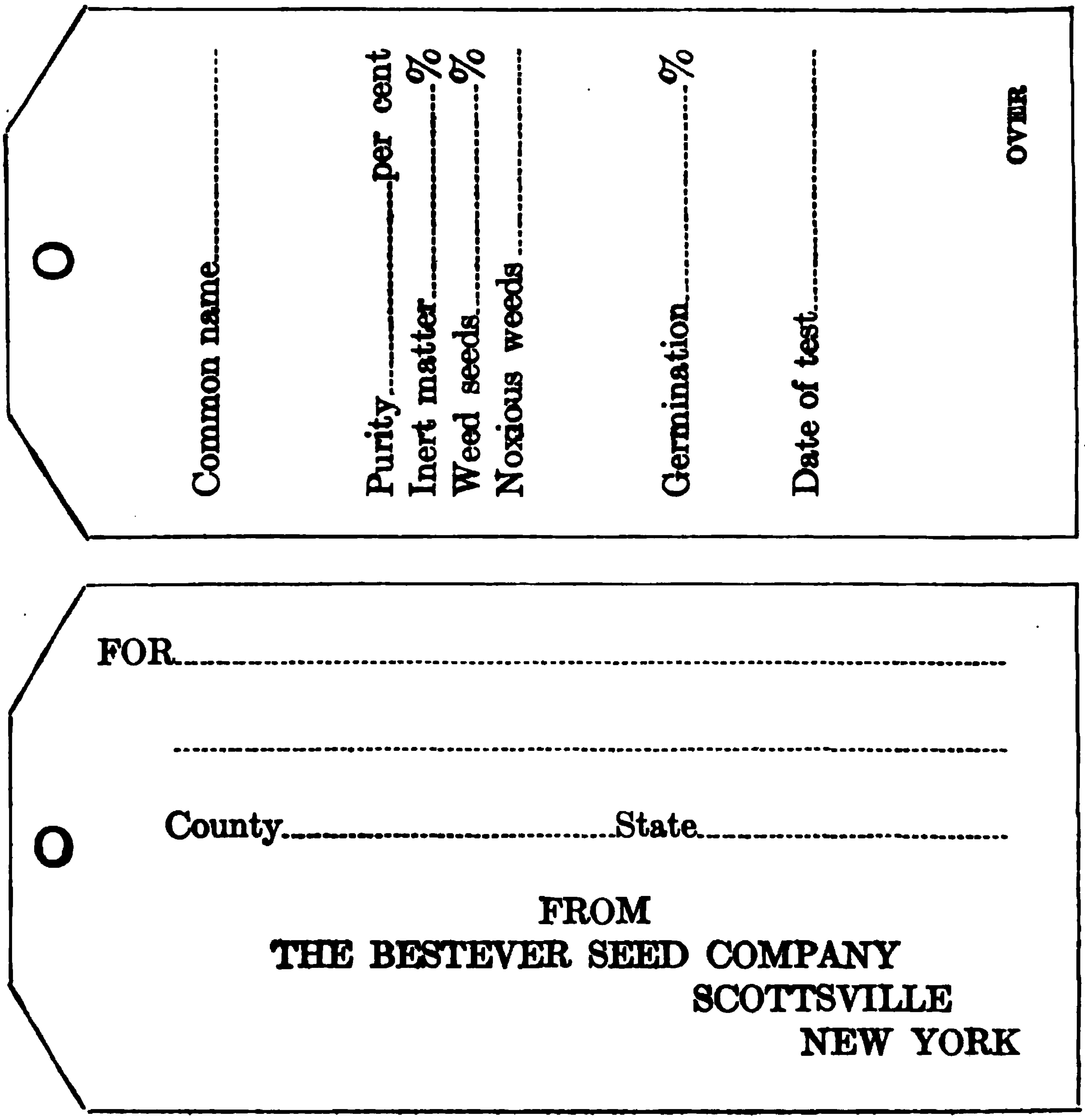


FIG. 19.—FRONT AND REVERSE SIDE OF GENERAL TAG OR LABEL SUITABLE FOR USE WITH ALL CLASSES OF SEEDS LABELED UNDER THE LAW.

EXEMPTIONS FROM THE SEED LAW

In order that there may be no misunderstanding as to the exemptions from the provisions of the seed law, the text of the law regarding exemptions is hereby quoted in italics and followed by explanatory notes.

Section 344.— *Exemptions. Agricultural seeds or mixtures of same shall be exempt from the provisions of this article:*

1. *When exposed for sale or sold for food or feeding purposes only.*— No labels are required under the seed law when seeds are sold, offered, or exposed for sale for food or feeding purposes; however,

just so soon as such seeds are sold, offered, or exposed for sale for seeding purposes on the land then the complete label must be attached.

2. *When sold to be recleaned before being sold or exposed for sale for seeding purposes.*— No labels are required when seeds are sold to elevator men, merchants, seed dealers, etc., to be recleaned before being sold, offered, or exposed for sale for seeding purposes. In such cases the dealer or other person who recleans the seed to put it into salable condition for planting purposes must have the lot tested and must completely label each parcel of 10 pounds or more before it is placed on sale or sold. In other words, any farmer can sell his seed stocks of his own growing to any merchant to be recleaned without the necessity of labels; however, as soon as he takes it from his farm or sends it by common carrier to another for *seeding purposes*, then he becomes a vendor, and both the seller and the seeds are subject to all the provisions of the seed law.

3. *When held for the purpose of recleaning.*—When seeds are held in storage in any form or place for the express purpose of recleaning no labels are required until the seed is recleaned, held for sale, offered for sale, or sold for seeding purposes, then such goods must have the required label information.

4. *When such seeds consist of buckwheat, barley, corn, oats, rye, wheat, or other cereal sold by the grower thereof on his own premises and delivered to the vendee or his agent or representative personally on such premises.*—The meaning and intent of this exemption is quite clear, making it possible for one farmer to sell his seed barley, buckwheat, corn, oats, rye, wheat, and other cereals (that is, those grasses which are grown for their grain, which is ground into flour) of his own growing, on his own premises, to a neighboring farmer or other person providing he personally delivers such seeds to the "vendee" (the buyer) on such premises, that is the premises of the grower. The farmer may be held responsible for any representations he may make regarding such seeds. It should be clearly understood that none of the grasses or clovers with smaller seeds and which are more apt to be fouled with weed seeds can be sold in this manner for planting directly on the land. [Furthermore, no farmer, grower, or any other person can legally sell, offer, or expose for sale seeds for seeding purposes either of his own growing or farmer-bought for delivery from his farm or premises, either per-

sonally, by agent, or by common carrier unless such lot of seed is less than 10 pounds in weight (8 ounces of special mixtures), or is sold to be recleaned, or is fully and completely tagged with the required label information.]

THE WORD "APPROXIMATE" DEFINED

In certain of the provisions of the law when a percentage statement is required the word "approximate" appears as a qualifying word before percentage composition and before germination. The use of this word is based upon the fact that tests for purity or germination of seeds when made even by the same person, upon samples taken under identical conditions and circumstances from the same lot of seed, the same part of a bag, and even from different portions of a well mixed bulk, will always vary to a certain extent. In other words no analyst, however carefully the work may be done, is able, except by chance, to get the same results each time a test is made. Certain variations are expected in the seed and allowances must be made for these variations. The allowances, or tolerances, which may be permitted under the meaning of the word approximate when tests made in the State's seed testing laboratory are compared with the analysis statements on the tag, are considered under a definite expression or formula termed the "latitude of variation" or "tolerance." This expression, which defines provisionally the use of the word approximate, and its manner of application will be found on page 328. The formula given was adopted by the Association of Official Seed Analysts of North America and is recommended for general use.

Every purchaser of seeds should bear these facts in mind when comparing a report of a test with the analysis statements on the tag or label of any lot of seed on the market.

FARMERS NOT EXEMPTED FROM THE SEED LAW

Farmers are not exempt from the seed law except as provided for in subdivision 4 of the exemptions discussed on page 328. The farmer should not be and is not fully exempted from the provisions of the seed law when he offers for sale seeds which are intended to be used immediately for seeding or planting purposes without further cleaning. His seed stocks offered for sale for planting

purposes, except as above exempted, are subject to inspection and retest the same as those of any vendor of seeds, and his premises are also subject to inspection by authorized persons when there is reason to believe that the provisions of the seed law are being violated. He has not asked to be exempted and does not care to be since he has need of a strict seed law every time he purchases seeds for planting, whether of a dealer or of a neighbor. Seed laws which fully exempt the farmer have been found unconstitutional in other states. The careful, thrifty farmer demands, and rightly so, all the information about his contemplated seed purchase that is required to be given by the seed law. If a farmer, who is the grower thereof, desires to sell certain kinds of seeds to a neighbor without any label or quality information, and both care to deal in that manner, then they alone are responsible, the one for obtaining full price value for his goods and the other for the noxious and troublesome weeds he may get along with seed of possibly low or unknown germination.

SEED INSPECTION AND LAW ENFORCEMENT

The seed law, being an article of the State agricultural law, provides for the unobstructed inspection of any lot of seed in any place or upon any premises, the authorized representatives or agents of the Commissioner of Agriculture having access at all reasonable hours to such premises. Samples of seeds, properly drawn according to the rules for sampling seeds, may be taken in duplicate for the express purpose of examination, analysis, or test. Such tests are reported to the Commissioner of Agriculture who is empowered to administer the law in case he has reason to believe that its provisions have been violated.

RESULTS OF TESTS MAY BE PUBLISHED

The law provides for the publication from time to time of the results of the analyses or tests of samples of seeds procured on the market. This is done in order that the purchaser may study and compare the seed dealers' promises and performances from year to year. Additional information regarding the general condition of the quality of seeds and the seed trade may also be published with these reports if deemed necessary.

HOW A FARMER MAY SELL SEEDS

A farmer who is a grower of seeds and desires to sell them for seeding purposes may do so in a number of different ways.

1. He may sell any seeds to anyone, anywhere, for use for food without labels, or for seeding purposes when in less than 10-pound lots.

2. He may sell, ship, or deliver field seeds to any merchant or general market to be recleaned or graded before being offered for sale for seeding, just as he has always done.

3. He may sell buckwheat, barley, corn, oats, rye, and wheat seed or other cereal of his own growing to any person providing the seed is delivered personally to the buyer or his representative upon the premises of the grower.

4. He may sell any kind of seed for seeding purposes to anyone, anywhere, either to be delivered personally or shipped thru a common carrier providing he has either tested such seed, or has had a test made, as he should do, and has fully labeled each lot.

HOW A FARMER MAY BUY SEED

The law does not forbid any person from buying the cheapest and foulest seed upon the market or dead and trashy seed, if he cares to do so, nor does it shield him from his folly if he now buys seeds carelessly and without taking full advantage of the protection afforded by the seed law. Every lot of seed upon the market in this State must be fully labeled, and no farmer should accept such seed until he has made an examination of the statements on the tag or label. In case these statements are not given he should insist upon receiving such quality information as required by law and should promptly report to the Commissioner of Agriculture at Albany any persons or dealers who are violating the seed law or ignoring its provisions.

The most important consideration which the farmer can possibly give to seed purchases is in the matter of the grade of seed. When a tag or label bears a statement that the seed is above 99 per cent pure, and since the farmer can find out, if he will, whether such a statement is true, he may be sure that he is buying fairly safely. However, when he buys seed which is labeled with a low percentage of purity, he may be certain that he is either buying dirt at seed prices,

or else is getting a grand array of weed seeds which will most certainly bring him a huge expense bill in the form of eradication effort for years to come. Usually a low purity guaranty means cheap, but really costly, seed; and cheap seed, like cheap fertilizer, is always expensive. This is necessarily so since the competition on the seed market is so keen that seed grades are based very nearly on their actual value. There are no bargains in the seed market because cheap seed is cheap for the reason that it is poor in quality, and any farmer who buys cheap seed in order to save money is like the man who stops the hands of the clock to save time — there is no saving. Likewise, any farmer or grower who produces foul and dirty seed cannot expect a dealer to pay a high market price if he is forced to spend time and money in cleaning out dirt and inert matter, weed seeds, and the light trashy stuff that nearly always remains in seed when threshed.

Finally, the farmer should *buy good seed* of a desired and known kind or variety, fully and completely labeled. He should grasp the idea that purchased weed seeds and inert matter are highly expensive; furthermore, that buying "cheap seeds" carelessly, absolutely prevents one from having any control of the weeds upon the farm. On and after July 1, 1920, it will pay every New York farmer to buy his farm seeds of the local dealer, retailer, or State wholesaler, since they will sell their grades of seed under an honest and correct label as required by the State law. On the other hand, if a farmer sends outside the State for his seed he buys at his own peril because the out-state dealer sends seeds into this State under the freedom of interstate commerce and is immune to local prosecution except where contract of sale is made within the State. State laws do not regulate interstate commerce, consequently the only protection for the farmer who sends for seeds outside the State is the reliability of the house with which he deals.

PURCHASERS MAY HAVE SEEDS TESTED

Anyone who purchases seeds for his own planting purposes may have them tested free of charge according to the rules and regulations for seed testing adopted by the Station officials as given on page 26. However, no person should send samples for testing until he is familiar with the rules for the sending of such samples. Since the

seed law is primarily a labeling law it should be entirely possible for the purchaser to rely quite largely upon the label statements found upon the lots of seed in the hands of the local dealer or other persons favorably known to the purchaser. Plainly it should not be the function of the Station seed laboratory to be continually retesting labeled goods or recognized brands or lots of seeds found upon the market when there is no evidence to show that such label statements are incorrect, or where the date of the germination test does not show sufficient time to have elapsed to effect materially the germinative ability of the seeds.

If, in any case, the purchaser of seeds has good and sufficient reason to believe that the label markings are not true statements of facts concerning the seed, or that sufficient time, as shown by the date of the test, has elapsed to effect materially the viability of the seed, he may have them tested free of charge according to Rule 8, page 335.

Samples sent in for testing will be reported upon strictly in the order in which they are received. The report will include a statement of the purity of the sample, that is, it will give the percentage of pure seed, the percentage of weed seeds, the percentage and character of the inert matter, and the number per pound of crop seed of noxious weed seeds present.

The percentage of germination, or the number of seeds per 100 selected just as they come which will sprout in the normal number of days, will be stated on the report if a germination test is requested. The percentage of hard seeds, that is, those seeds which remain hard (having neither sprouted, swollen, nor decayed) at the end of the test period will also be given.

When it seems to the interest of the farmer or purchaser to do so, some additional remarks or comments as to the condition or quality of the seed will be made upon the report.

DUTIES OF THE SEED WHOLESALER, RETAILER, AND DEALER

Under the new seed law every retailer, dealer, implement dealer, or hardware or groceryman who sells seed is absolutely required to see to it that every lot of agricultural seed of 10 pounds or more sold, offered, or exposed for sale in his store shall be correctly labeled or tagged. Therefore, the retail seedsman should insist that the

wholesaler label his goods under the New York law, since if he is a New York wholesaler he can be held responsible for his unopened original bag of seed in the retail store. The local retailer or dealer should provide himself with blank or form labels upon which he can either print, stencil, rubber-stamp, typewrite, or write out the information required by the seed law in case his sales are not the unopened and original bags of seed bearing the wholesalers' label made out completely as to the New York seed law requirements. Forms of such tags are given on page 316. In either case, the retailer must place the moral responsibility upon the wholesaler or upon himself as the case may be. The retailer alone is responsible for unlabeled farmer-bought, or for unlabeled and untested seeds from outside the State. He must have such seeds tested and correctly label them. The local merchant, in any case, is personally responsible for the absence of the legal tag on any sale of farm seeds of 10 pounds or more. Conditions and rules under which such seeds are tested are given on page 334.

SEED TESTING

OBJECT OF SEED TESTING

The object in testing any particular lot of seed is to determine, as nearly as possible, before the seed is planted, the productivity of a given lot. The seed itself is considered one of the very important factors in crop production. At least two qualities (purity and germination) or more, which influence the value of a crop, may be definitely determined by testing. Therefore, it cannot be too strongly urged that farmers, both in their own interests and in the interests of national food production, send samples of all seeds of unknown or doubtful quality to be tested some time before they sow them.

METHOD OF SEED TESTING

The Commissioner of Agriculture, who is empowered to make such rules and regulations as are necessary to secure the efficient enforcement of the seed law, has provided that for all seed testing done under the new seed law the "Rules for Seed Testing" recommended and followed by the Association of Official Seed Analysts of North America shall be used. This rule having been established, the rules for seed testing in vogue by the above named association

will be used by the seed testing laboratory at this Station. In order to prevent excessive variation due to different methods of testing it is recommended that seedsmen and others doing their own testing employ the rules and methods adopted by the State seed testing laboratory as printed below.

RULES FOR SEED TESTING[1]

PURITY TESTS

Taking of Samples

Failure to secure representative samples is one of the most common causes of variation in tests of seed. The following directions for sampling are recommended.

1. The minimum weight of seed forwarded for test should be approximately:
(a) one ounce of grass seed of any kind or of white and alsike clover;
(b) two ounces of red and crimson clover, alfalfa, millet, flax, or seed of like size;
(c) one-half pound of cereals or seed of like size.

2. Samples must be drawn so that they will represent as accurately as possible the bulk lot from which they are taken. They may be drawn:
(a) with seed triers which must be long enough to extend at least three inches into the bag; or,
(b) with long stickers which, when used for bags, will be extended from the top toward the bottom near the center; or,
(c) by hand, according to the circumstances described below.

3. Closed bags of clovers, grasses, and other small seeds may be sampled:
(a) with a seed trier, taking approximately equal parts from near the top, near the middle, and near the bottom; or
(b) with a long sticker.

4. Open bags, full or nearly so, may be sampled:
(a) by taking approximately one-third of the sample from the top of the bag by hand or with a seed trier, one-third from near the middle, and one-third from near the bottom with a seed trier; or,
(b) with a long sticker.

5. Bags partly emptied may be sampled:
(a) with a long sticker;
(b) by dumping out contents and mixing before sampling.

6. Sacks of grain or other large seeds may be sampled:
(a) with a long sticker; or,
(b) by hand, taking approximately equal parts of the sample from at least three different places in the sack, including the top and opposite sides as near the bottom as practicable.

7. If a bag full or nearly so is to be sampled and no seed trier or sticker is available, the contents may be emptied out and approximately equal parts taken from at least three places in the pile, top, center, and edge.

8. Any seed loose in boxes, barrels, bins, cars, or other receptacle may be sampled by taking approximately equal parts from at least three different places by hand, the top, center, and edge, or with a long sticker as circumstances may require.

9. Field, root, garden vegetable, or other seeds in carton boxes or paper bags may be sampled by emptying out the contents and taking seed from at least three different places to make up the sample. With paper packet seeds the whole package should be sent.

10. If the seed drawn from different parts of a lot is in excess of the amount required for a sample, it must be thoroly mixed before the sample to be sent for analysis is taken from it.

---

[1] Recommended by the Association of Official Seed Analysts of North America at its 10th Annual meeting held at Detroit, Michigan, June, 1917. Revised Jan. 1919.

11. Samples should be drawn from each bag when there are not more than five bags in the lot, from every fifth bag when there are more than five bags, but never from less than five bags. Each sample so drawn may be kept separate and given a designation mark (such as a, b, c, etc.) or combined proportionately into one composite sample.

Light

Testing seeds for mechanical purity requires the constant use of the eyes in distinguishing seeds by their external characters. In order that this work may be done with the least possible eyestrain and the greatest comfort to the worker, a uniform source of light without direct sunshine or shadows is required. This is best obtained at laboratory tables in front of north windows with the workers facing the windows.

Amount of Seed Used

All purity tests should be made by weight from smaller lots taken from the samples submitted. The minimum quantities used should be not less than those given below and should be taken from the sample submitted for test by use of a mechanical mixer and sampler. The sample should be repeatedly divided with the mixer and sampler until approximately the amount required for the test is obtained. The whole of this should then be used for the test making the sampling entirely mechanical.

When the analysis indicates that a law is violated or that the labeling is incorrect a duplicate test should be made.

(a) *One gram*: *Agrostis spp.*, *Poa spp.*, yellow oat grass, tobacco.

(b) *Two grams:* Bermuda grass, velvet grass, timothy, meadow foxtail, crested dog's tail, orchard grass, sweet vernal grass, alsike clover, white clover, *Umbelliferae*, and all the fescues except meadow fescue.

(c) *Five grams:* All grass seeds not enumerated elsewhere, together with *Melilotus spp.*, *Medicago spp.*, *Lespedeza spp.*, millet (*Chaetochloa italica*), lettuce, and all clovers except white and alsike and crimson.

(d) *Ten grams:* *Cruciferae* and flax, crimson clover, millet (*Panicum miliaceum*).

(e) *Fifty grams:* Buckwheat, *Vicia spp.*, *Lathyrus spp.*, beet "balls," esparcet, lentils, sunflower, teosinte, serradella, vine seeds, and all cereals except corn.

(f) *Five hundred grams:* Peas, beans, white lupine, cowpeas, cotton, and corn.

Amounts to be taken of seeds not enumerated should be the same as those required for seeds named which are of similar size.

The determination of the number of seeds of the individual noxious weed seeds (including dodder) per unit weight should be made on the entire sample or the following minimum quantities for the various classes of seeds, unless more than five are found in the portion previously examined:

(a) 25 gms. (b) 50 gms. (c) 50 gms. (d) 50 gms. (e) 250 gms. (f) 500 gms.

Method of Testing

When the smaller average lot has been weighed, it should be separated; either by hand or mechanically and by hand, into 4 parts: pure seed, inert matter, seeds of other cultivated plants, and weed seeds. After separation has been made into these four component parts, the percentage by weight of each should be determined and recorded.

In cases where the reports issued require only a statement of the kinds and number for a given weight of weed seeds or other impurities without a percentage of purity determination the method may be varied accordingly.

Pure seed: Seed of the kind being examined. All seeds of the kind being examined should be considered pure seed without respect to their apparent condition, whether shriveled, cracked, or otherwise injured, except that in the case of cracked seeds, any piece larger than one-half should be considered as a pure seed, and pieces one-half or less should be considered as inert matter except, further, that decorticated seeds of red and crimson clover and cracked seeds of sorghum should be considered inert matter.

Inert matter: Broken seeds, one-half or less and decorticated leguminous seeds, dirt, stones, chaff, and any other matter not seeds. In testing grass seeds, empty

glumes should be considered as inert matter and only glumes containing caryopses (grains) considered as pure seeds. The presence or absence of caryopses may be determined by pressing each glume between forceps or between the finger nail and the table, or with transmitted light by means of the mirror box. Sterile glumes of grass seeds to be separated from fertile glumes and put with inert matter.

Seeds of other cultivated plants: The seeds of other cultivated plants should be separated and identified, the total percentage by weight determined, and the number or weight of each kind recorded.

Weed seeds: Seeds of weeds should be separated and identified, the total percentage by weight determined and the number or weight of each kind recorded.

Adulterated samples: As seeds used as adulterants usually closely resemble the seed with which they are mixed, the making of purity tests of adulterated samples by the above method is slow and tedious, and the following shorter method is permitted: After the smaller average lot has been weighed out, separate the seed into four parts: (1) Pure seed and adulterants; (2) inert matter; (3) seeds of other cultivated plants; (4) weed seeds. From the mixture of pure seed and adulterants, count out 500 seeds indiscriminately and separate the adulterants from the pure seed. The percentage of each may be determined by their proportional number if seeds of adulterants and pure seed are of approximately the same weight but the determination is preferably made by weight in all cases.

Latitude of variation: The following method shall be followed in determining the latitude of variation in any one of the four component parts into which a sample is separated in making a purity test and in determining the proportion of adulterants present. For each determination the sample shall be considered as made up of two parts (1) the element being considered and (2) the balance of the sample. In determining the tolerance for *weed seeds*, the sample shall be considered as being made up of two parts (1) weeds seeds and (2) everything not weed seeds. In determining the tolerance for *inert matter*, the sample shall be considered as being made up of two parts (1) inert matter and (2) everything not inert matter. In determining the tolerance for *seeds of other cultivated plants*, the sample shall be considered as being made up of two parts (1) seeds of other cultivated plants and (2) everything not seeds of other cultivated plants. In determining the tolerance for *pure seed*, the sample shall be considered as being made up of two parts (1) pure seed and (2) everything not pure seed.

The tolerance allowed shall be in the case of pure seed, weed seeds, inert matter, and seeds of other cultivated plants, two-tenths of 1 per cent plus 20 per cent of the lesser part.

With samples of seed labeled with a guaranteed percentage germination the maximum latitude within which the stated percentage germination may be considered as correct shall be the same as the allowable variation between duplicate germination tests defined in Table I herein.

GERMINATION TESTS

The following methods for making germination tests are not made official but are recommended by the Association:

Seed Used, Source, and Quantity

In making germination tests the entire amount of pure seed obtained in making purity test should be thoroly mixed and 100 seeds, or 200, according to size, should be taken indiscriminately for each of the duplicate tests.

Duplicate Tests and Allowable Variation

Germination tests should be made in duplicate simultaneously under identical conditions, preferably in separate germinating chambers, and the average percentage of germination of the duplicates should be recorded on the record sheet. If the duplicate tests vary more than the percentage provided below a retest should be made and a supplementary test in sand or soil is also recommended.

TABLE I.—ALLOWABLE VARIATION BETWEEN DUPLICATE GERMINATION TESTS.

PERCENTAGE OF GERMINATION	PERCENTAGE OF ALLOWABLE VARIATION
90 or over	6
80 or over and less than 90	7
70 or over and less than 80	8
60 or over and less than 70	9
50 or over and less than 60	10
40 or over and less than 50	10
30 or over and less than 40	9
20 or over and less than 30	8
10 or over and less than 20	7
0 or over and less than 10	6

A retest should always be made when there is evidence of poor germination at the time of making the first count. It is also recommended that retests be made simultaneously with a test of a sample which is known to germinate well.

Substratum or Seed-bed

Chamber tests: Two kinds of substrata should be used for chamber tests: (1) Canton flannel of medium weight, cut in strips 8 by 32 inches and folded twice lengthwise, should be used for peas, beans, corn, lupines, cotton, cowpeas, and other seeds of similar size. (2) Blue blotting paper, 120 pounds to the ream, free from injurious chemicals and water soluble dye, cut in strips 6 by 19 inches and folded twice lengthwise, should be used for all small seeds. Blotting paper should be used only once.

The bell jar method: Blue blotting paper.

Daylight germinator: Blotting paper, porus clay dishes, sand, and soil are used as substrata in testing seeds in the daylight germinator.

Sand tests: The sand used should be free from organic matter, sifted to a uniform size of approximately 1 mm. and sterilized by steam.

Soil tests: The soil used should be composed of loam, sand, and leaf mould in proportions to give a light soil with good moisture holding capacity, sifted to remove all coarse material, and sterilised by steam.

Placing seed in substrata: All seeds should be placed far enough apart to avoid contact during the process of germination.

Chamber and bell jar tests: Seeds of *Agrostis spp.*, *Poa spp.*, timothy, tobacco, and others of similar size should be placed on top of blotters. All the larger seeds should be placed between the folds of blotting paper or cloth.

Daylight germinator: All small seeds should be placed on top of blotters, sand, porus clay dishes, or soil.

Sand and soil tests: Seeds of *Agrostis spp.*, *Poa spp.*, timothy, tobacco, and others of similar size should be sown on the surface and the lightest possible covering of sand given them. All the larger seeds should be planted at depths about equal to twice their greatest diameter.

Moisture

The blotting paper, filter paper, cloth, sand, or soil used as a substratum should be kept well moistened, but not saturated, during the time of germination test. In sand tests, the flats should be shaded from the direct rays of the sun to prevent rapid evaporation from the surface and consequent drying out of the surface. Moisture

should be supplied by subirrigation. Uniform results can not be obtained if the flats are exposed to the direct sun, or the surface is washed as is the case when watered from a hose or sprinkling pot.

Alternating Temperatures

Chamber tests: When alternating temperatures are used the seeds should be kept at the lower temperature for approximately 18 hours and at the higher temperature for approximately 6 hours each day.

Sand tests: All sand tests should be made in a room or greenhouse where the temperature is as nearly as possible that used for incubator tests of the same kinds of seeds.

Counting Sprouts

Light germinator, chamber and bell jar tests: The sprouted seeds should be counted and removed as nearly as possible as follows:

On 2nd and 4th days for 4 day tests
3rd and 5th days for 5 day tests
3rd and 6th days for 6 day tests
4th and 8th days for 8 day tests
5th and 10th days for 10 day tests
5th, 10th, and 14th days for 14 day tests
7th, 14th, and 21st days for 21 day tests
7th, 14th, 21st, and 28th days for 28 day tests

Seeds of Leguminosae should not be considered germinated when both cotyledons break off.

Sand and soil tests: Only those sprouts should be counted which appear above the surface of the sand or soil. The sprouts should not be removed at the time of making the preliminary report.

Supplementary Tests

Supplementary tests in sand or soil are recommended in the case of all seeds which do not germinate well in the chamber, bell jar, or light germinator tests. The results of the supplementary tests should be accepted when they show a higher percentage than the chamber tests.

Sterilisation

All cloths, bell jars, and other apparatus used in connection with germination tests should be carefully sterilised with steam or boiling water before using. Blotting paper should be used but once.

Hard Seeds

In reporting the germination of samples of leguminous seeds, a portion of which usually remain hard at the end of the test, the actual percentage of germination should be reported and also the percentage of seed remaining hard.

Substrata, Temperatures, and Duration of Tests

Table II gives the substrata, optimum temperatures, and days on which both preliminary and final reports should usually be made on chamber, bell jar, and light germinator tests of the common seeds. Tests in which there are no hard seeds should be continued until all seeds either sprout or decay. For sand and soil tests a longer time should be allowed for preliminary and final reports.

TABLE II.— SUBSTRATA, TEMPERATURES, AND DURATION OF TESTS.

KIND OF SEED	SUB-STRATUM†	TEMPERATURE, CENTIGRADE	DAY FOR MAKING GERMINATION REPORT	
			Preliminary	Final
Field Crops*				
Barley	B	20	3	5
Beans	C	20–30	3	6
Beets *b c*	B	20–30	5	10
Buckwheat	B	20–30	3	5
Corn	C	20–30	3	5
Cotton	C	20–30	4	7
Flax	TB	20–30	2	5
Hemp	B	20–30	3	5
Oats	B	20	3	5
Peas	C	20–30	4	8
Rice	B	20–30	3	6
Rye	B	20	3	5
Tobacco	TB	20–30	7	14
Turnips	B	20	3	5
Wheat	B	20	3	5
Grasses, Clovers, Forage Plants				
Alfalfa	B	20	3	5
Bermuda grass	BJ	20–35	10	21
Bluegrass	BJ	20–30	14	28
Brome grass	B	20–30	5	10
Clover, alsike	TB	20	3	5
Clover, crimson	B	20	2	4
Clover, mammoth red	B	20	3	5
Clover, common red	B	20	3	5
Clover, white	TB	20	3	5
Cow peas	C	20–30	4	10
Crested dogtail	B	20–30	10	18
Meadow fescue	B	20–30	5	10
Other fescues (*ovina* group)	B	20–30	10	21
Meadow foxtail	B	20–30	6	10
Millet	B	20–30	3	5
Johnson grass	B	20–35	6	10
Orchard grass	B	20–30	6	14
Paspalum	B	20–35	6	14
Rape	B	20	3	5
Redtop	TB	20–30	5	10
Rescue grass	BJ	20–35	10	21
Rhodes grass	B	20–30	6	10
Rye grass	B	20–30	6	10
Sorghum	B	20–30	3	5
Sudan grass	B	20–30	3	5
Soy beans	C	20–30	4	8
Sweet vernal grass	B	20–30	6	14
Tall meadow oat grass	B	20–30	6	10
Teosinte	B	30	4	8

TABLE II.— SUBSTRATA, TEMPERATURE, AND DURATION OF TESTS (*concluded*).

KIND OF SEED	SUB-STRA-TUM†	TEMPERA-TURE, CENTI-GRADE	DAY FOR MAKING GERMINATION REPORT	
			Prelim-inary	Final
Grasses, Clovers, Forage Plants — *continued*				
Timothy	TB	20–30	5	8
Turnips	B	20	3	5
Velvet grass	B	20–30	6	10
Vetch	C	20–30	4	14
Vegetables				
Asparagus	C	20–30	6	14
Beans	C	20–30	3	6
Beets *b c*	B	20–30	4	10
Cabbages	B	20	3	5
Carrots	B	20–30	6	14
Cauliflower	B	20	3	5
Celery	TB	20–30	10	21
Cucumbers	B	20–30	3	5
Eggplant	B	20–30	8	14
Kale	B	20	3	5
Lettuce *b*	B	20	2	4
Muskmelons	B	20–30	3	5
Okra	C	20–30	4	14
Onions	B	20–30	4	7
Parsley	B	20–30	14	28
Parsnips	B	20–30	6	21
Peas	C	20–30	3	6
Peppers	B	20–30	4	10
Pumpkins	C	20–30	3	6
Radishes	B	20	3	5
Salsify	C	20–30	5	10
Spinach	B	20	5	10
Squashes	C	20–30	3	6
Sweet corn	C	20–30	3	5
Tomatoes	B	20–30	4	10
Turnips	B	20	3	5
Watermelons	B	20–30	4	6

* In the case of cereals and timothy grown under such conditions that they are frosted or exposed to cold weather before harvest, the germination tests should be made at lower temperatures, 15 to 20° C., and continued for longer periods than for normal seed.

† B — Between blotting paper.
TB — On top of blotting paper.
BJ — Bell jar (these seeds may also be germinated in daylight germinator).
C — Between folds of cloth.

b — Soak six hours in water at room temperature before testing for germination.

c — It is recommended that the germination of beet seed be confined to determining the percentage of balls which give sprouts.

Keeping Samples

The original sample should be kept in a dark, dry, cool place for six months for use if a retest is found necessary. The separations made in making the test should be enclosed in envelopes or vials and filed for reference.

Record Sheets

A record sheet should be kept for each sample, on which should be recorded the serial test number, the sender's identification mark, the name of the seed, the name and address of the sender, the year and place of growth, if known, the weight of the smaller average lot used in making the purity test, the percentage by weight of pure seed, the percentage by weight and the character of the inert matter, the percentage by weight of other crop seeds and of weed seeds with a memorandum of the number or percentage of each, the temperature and kind of substratum, the number of seeds germinated and the time each count was made, the average percentage of germination and the day of the test upon which the preliminary report was made, the number of seeds remaining hard at the close of the test, and the total average percentage of germination and the duration of the test, the presence of weak sprouts and mould, or such information as is required for the report.

REPORTS

All reports should show the date of receipt of the sample, the serial test number, the sender's identification mark, and the common name of the seed.

Purity Test Report

This should show the percentage by weight of the pure seed, the percentage by weight and character of the inert matter, the percentage by weight of seeds of other cultivated plants, and the percentage by weight of weed seeds. The quantity of each important foreign seed present should be shown and special attention should be called to the seeds of all noxious weeds, or such information as is required by law to be given with seed offered for sale where the report is issued.

Germination Test Report

This should include the duration of the germination test, the average percentage of germination, and the percentage of hard seeds if any.

PROVISIONS FOR SEED TESTS

The seed law grants permission to the New York Agricultural Experiment Station at Geneva to establish and maintain a seed laboratory with necessary equipment, and to employ competent analysts to make analyses and tests of samples of seeds collected under the provisions of the seed law. Since 1905, this Station has made tests of seeds voluntarily and free of charge for farmers or purchasers of seed when the sample and the accompanying request for a test bore every evidence of being desired by the prospective sower of the seed. Samples in increasing numbers and to the extent of several hundred per year have been tested under this policy. It is to be hoped that farmers in increasing numbers will appreciate and will continue to take advantage of the facilities offered by the

seed law in a provision for a seed testing laboratory where their seeds may be tested. Means and facilities have not been available with which to undertake testing for seed dealers and the general seed trade. Since 1912, when the first seed law was enacted in this State, tests of samples collected officially from the open market have been analyzed at this Station as provided for in the law, however, no provision was made for the operation of a seed testing laboratory.

Provision is also made in the new law whereby any citizen of the State shall have the privilege of submitting to the seed laboratory at the New York Agricultural Experiment Station at Geneva, samples of agricultural seeds for test or analysis. This privilege is subject, however, to such rules and regulations as may be adopted by the Director and Board of Control of said Station. These officials are granted power to make such rules and regulations as may from time to time become necessary to protect the seed laboratory and to facilitate service for the greatest number of people by limiting the number of samples tested for any one individual in a given time, and also to fix the fee charged for making tests of samples other than those tested free of charge.

Rules and regulations adopted by the Director and Board of Control of the Station for the use of the seed testing laboratory are given below. Unless these rules and regulations are strictly observed delay in testing will result, or the samples may receive no attention at all. No tests will be made for persons violating any of the regulations.

RULES AND REGULATIONS GOVERNING THE TESTING OF SEEDS FOR PURITY AND GERMINATION [1]

1. The kinds of seeds that will be tested are those specified in the Seed Law and, in addition, the seeds of garden and truck crop plants.

2. Samples to be tested should be drawn in such a way as to be fairly representative of the bulk lot of seed from which they are taken. (See "Rules for Sampling," page 326.)

3. Only samples which are of sufficient size for taking a representative test-sample will be analysed or tested. The minimum weight of seed forwarded for test should be approximately:

---

[1] Adopted by the Director and Board of Control of the New York Agricultural Experiment Station, June 1, 1920.

(a) One ounce of grass seed of any kind or of white and alsike clover;

(b) Two ounces of red and crimson clover, alfalfa, millet, flax, or seed of like size;

(c) One-half pound of cereals or seed of like size.

4. Each sample must bear an identification mark, the name of the kind of seed, and the name and address of the sender. Also, it must be accompanied by a statement of what is desired — whether a purity test, a germination test, or both.

Samples sent by mail or express must be fully prepaid and should be enclosed in stout containers which will insure their arrival unbroken.

Address all samples and correspondence relating thereto to the Seed Laboratory, New York Agricultural Experiment Station, Geneva, N. Y.

5. The name of the Station, of the Seed Laboratory, or of a Station official must not be used for advertising purposes in connection with the report issued upon any sample of seed.

The data on the report may be copied onto a tag or label for the purpose of a declaration of sale, but the party doing this thereby guarantees that the quality of the seed to which such label is attached equals that indicated by the label.

6. Samples of seed grown by residents of New York State for their own use will be tested free of charge. Such samples must be accompanied by a statement that the test is not desired for use in a declaration of sale or for purposes of labeling, but for guidance in planting.

7. For all tests the results of which are to be used for declarations of sale or for labeling purposes, a fee will be charged as follows: For purity tests of special mixtures and all grasses (except timothy and the cereal grains), one dollar each; for purity tests of timothy cereal grains, and all other kinds of crop seeds (except grasses), fifty cents each; for all germination tests, twenty-five cents each. Remittance should be made by money order payable to the State of New York.

8. Only under special circumstances which seem to justify such analyses in order to check guarantees, will the Station make tests (other than the regular official tests) of labeled seeds offered for sale upon the market. Persons making request for such tests should

state fully their reasons therefor and furnish the following information in addition to that required under paragraph 4:

(a) Name and address of the party offering the seed for sale;

(b) A complete copy of the label on the seed;

(c) The commonly accepted name of the seed, its variety, and place where grown, if known.

9. No more than five samples will be tested free for any one person in any calendar month, but such persons may have additional samples tested upon payment of the required fees. To avoid errors and consequent delays in testing, senders of samples should keep a record of their sendings.

10. No notice will be taken of samples which are unaccompanied either by a fee or the statement required for free-test samples as given in paragraph 6.

REPORT

OF THE

Department of Chemistry

L. L. Van Slyke, *Chief in Research (Chemistry).*

R. F. Keeler, *Associate in Research (Chemistry).*

A. W. Clark, *Associate Chemist.*

M. P. Sweeney, *Assistant Chemist.*

Otto McCreary, *Assistant Chemist.*

W. F. Walsh, *Assistant Chemist.*

H. L. Winston, *Assistant Chemist*

M. G. Moore, *Assistant Chemist.*

N. F. True, *Assistant Chemist.*

TABLE OF CONTENTS

(See also Report on Inspection Work.)

REPORT OF THE DEPARTMENT OF CHEMISTRY

SOME OF THE EFFECTS OF THE WAR UPON FERTILIZERS *

L. L. VAN SLYKE

SUMMARY

A study of data regarding commercial fertilizers, collected during the years 1914 to 1919 inclusive, reveal facts showing some of the effects of the war upon commercial fertilizers.

1. Effect upon kinds. The number of complete fertilizers decreased each year, going from 614 in 1914 to 171 in 1919. The mixtures of phosphoric acid and potash practically disappeared by 1916, while mixtures of nitrogen and phosphoric acid appeared in relatively large number in 1916 and the following years. Acid phosphate brands increased, while nitrate of soda decreased, and potash salts entirely disappeared. Bone, blood and tankage decreased.

2. Effect upon composition. In complete fertilizers the average percentage of nitrogen decreased appreciably after 1915, while that of potash decreased greatly after 1914, and still more after 1916. The average percentage of available phosphoric acid increased considerably after 1914, but with some variation from year to year. The total percentage of available plant-food decreased continually after 1914.

3. Effect upon cost. The average retail cost of one pound of plant-food increased year by year continuously after 1914 in the case of complete fertilizers, going from 8.8 cents per pound in 1914 to 33.1 cents in 1919, an increase of nearly four fold. In the case of acid phosphate, nitrate of soda, bone, dried animal manures, etc., there was an increase in the retail cost of plant-food, but not relatively as great as in the case of complete mixed fertilizers.

INTRODUCTION

In 1914 a bulletin (No. 392) was published by the Station, giving facts regarding the composition and cost of plant-food constituents

* Reprint of Bulletin No. 471, January, 1920.

in commercial fertilizers. The data then published represent the last year of normal pre-war conditions. It is a matter of interest to know in what manner and to what extent these pre-war facts have been affected from year to year during the war and also during the year 1919. The data upon which our results are based were obtained in connection with the annual official collection and analysis of commercial fertilizers in New York State.

It should be kept in mind, in considering our results, that the facts given for any one year represent the market conditions prevailing during the summer and fall of the preceding year. Fertilizer manufacturers generally make most of their purchases for materials during the summer and fall for use in making the goods to be placed in the hands of consumers during the spring and summer of the year following. Thus, the fertilizers used in 1914 were made from materials purchased largely in 1913, when conditions were normal; while the fertilizers used in 1919 were made from materials purchased in 1918, when the maximum effects directly due to the war were in full force.

In studying the effects of the war upon commercial fertilizers, we shall consider them under three heads, (1) kinds, (2) composition, and (3) price. First, we shall consider complete mixed commercial fertilizers, and then such unmixed fertilizing materials as we have satisfactory data for during the war period.

KINDS OF COMMERCIAL MIXED FERTILIZERS AND MATERIALS

In the table following, we give the number of each kind of mixed commercial fertilizers and of unmixed fertilizing materials collected and analysed each year from 1914 to 1919.

Among the points of special interest attracting our attention in connection with the data contained in Table I, we notice the following:

1. *Total number of brands.*— The number of brands or samples decreased after 1914, dropping about 15 per cent, in 1915, 35 per cent in 1916 and 44 per cent in 1918.

2. *Complete mixtures.*— The number of complete mixed fertilizers decreased about 10 per cent from 1914 to 1915; 62 per cent in 1916; and over 70 per cent in 1918 and 1919. This decrease was due, of course, to the impossibility of obtaining potash after the German

supply was cut off in 1914. The supply of potash then on hand in America was carefully husbanded and made to go as far as possible, both by decreasing the number of commercial mixtures containing potash, and also by decreasing the amount of potash in such mixtures, as will be shown later.

TABLE I.—NUMBER AND KINDS OF COMMERCIAL FERTILIZERS AND MATERIALS.

KINDS.	1914	1915	1916	1917	1918	1919
1. Complete fertilizers	614	549	233	259	177	171
2. Mixtures of phosphoric acid and potash	117	76	2	0	3	28
3. Mixtures of nitrogen and phosphoric acid	0	0	227	252	218	227
4. Acid phosphate	57	54	69	69	71	77
5. Sodium nitrate	39	25	9	13	7	9
6. Bone	34	45	33	31	29	23
7. Potash salts	43	2	0	0	0	1
8. Tankage	20	22	12	27	10	9
9. Dried blood	14	9	7	3	1	0
10. Dried animal manures	9	11	10	17	12	16
11. Lime compounds	25	29	30	27	26	19
12. Wood ashes	4	4	2	3	1	0
13. Miscellaneous	28	39	14	7	6	8
Totals	1,004	865	648	708	561	588

3. *Incomplete mixtures.*—Previous to the year 1914, there had been an increasing number of commercial fertilizer mixtures containing only acid phosphate and potash salts, the number having risen to 117 in 1914. This dropped to 76 in 1915, and then these mixtures practically disappeared from the market until the year 1919, when a number again appeared. When these phosphoric acid and potash mixtures disappeared and also the complete mixtures greatly decreased in number, it was the inevitable consequence that mixtures containing only nitrogen and phosphoric acid should take their place. Such mixtures first appeared in 1916, and about equalled the number of complete fertilizers in 1916 and 1917; while in 1918 and 1919 the number of these mixtures of nitrogen and phosphoric acid considerably exceeded that of the complete mixtures.

4. *Acid phosphate.*— The number of brands of acid phosphate has appreciably increased from year to year since 1915, indicating a more extensive use.

5. *Sodium nitrate* decreased rapidly after 1915, owing to the increased demands in the manufacture of explosives.

6. *Potash salts* disappeared completely from the market in 1915.

7. *Animal materials*.— The number of brands of bone, tankage and dried blood decreased appreciably, owing, probably, to their increased use in commercial mixtures, largely as a source of nitrogen in the absence of a sufficient supply of nitrate of soda, ammonium sulphate and cyanamid.

The dried powdered animal manures, especially sheep manure, increased in number.

COMPOSITION OF MIXED FERTILIZERS

It is a matter of interest to observe in what manner the percentage of plant-food constituents in mixed fertilizers has changed during the period under consideration. In Table II we give the average percent of nitrogen, of available phosphoric acid and of potash in complete commercial fertilizers for each year, stating the average percentage guaranteed, and also that found. The total number of pounds of plant-food in 100 pounds of fertilizer is also given.

TABLE II.— COMPOSITION OF COMPLETE FERTILIZERS.

YEAR.	NITROGEN.		AVAILABLE PHOSPHORIC ACID.		POTASH.		Plant-food in 100 pounds.
	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Lbs.
1914	2.08	2.16	7.60	8.04	5.70	6.04	16.24
1915	2.20	2.23	8.22	8.62	2.90	3.08	13.93
1916	2.14	2.20	8.50	9.22	1.28	1.32	12.74
1917	2.06	2.18	8.51	8.96	1.45	1.48	12.62
1918	1.90	2.02	8.32	8.55	1.58	1.52	12.09
1919	1.79	1.89	8.24	8.70	1.59	1.61	12.20

The results embodied in Table II can be summarized as follows:

1. *Nitrogen*.—The average percentage of nitrogen remained quite uniform until 1918, averaging about 2.20 per cent each year; but in 1918 the average percentage dropped to 2.02, and in 1919, to 1.79. This was due to the impossibility of securing adequate supplies of nitrogen-carrying materials, since practically all nitrate and ammonia compounds were absorbed in the manufacture of explosives.

In comparing the average percentages guaranteed with those found, it is seen that the guaranteed amount was exceeded by amounts varying from 0.03 to 0.12 per cent each year, and averaging for the six years 0.08 per cent.

2. *Available phosphoric acid.*— The percentage of available phosphoric acid increased during the first three years, and then decreased somewhat. There was the evident intention on the part of manufacturers to increase the average percentage of available phosphoric acid, the increase over 1914 varying from 0.51 to 1.18 per cent and averaging 0.77 per cent.

The average percentage of available phosphoric acid found exceeded each year that guaranteed by amounts varying from 0.23 to 0.72 per cent and averaging 0.45 per cent.

3. *Potash.*— As would be expected, the greatest change in the plant-food constituents of commercial fertilizers was in the content of potash, owing to the complete cessation of imported potash materials. In 1914 the average percentage of potash in complete fertilizers was about 6, and this, in 1915, decreased one-half or about 3. In 1916 the percentage of 1914 had decreased to 1.32 or nearly 80 per cent. During the past three years the average percentage has been about 1.50.

The average guaranteed percentage of potash was exceeded by that found each year, except in 1918, where the amount found fell below that guaranteed by 0.06 per cent. In 1914 the guarantee was exceeded by 0.34 per cent, and in 1915 by 0.18 per cent, while in 1916, 1917 and 1919 the excess found was only 0.02 to 0.04 per cent. These figures indicate that an effort was made to use potash sparingly, and keep as close to the guarantee as possible without using any excess.

4. *Total plant-food.*— If we add the percentages of nitrogen, available phosphoric acid and potash, we obtain the number of pounds of plant-food in 100 pounds of fertilizer, as shown in the last column of Table II. These figures show a marked decrease in 1915, and a further decrease in the years following. From the discussion of Table II, given above, it is obvious that the decrease in total plant-food was due mainly to decrease of potash, tho in 1918 and 1919 this was further accentuated by appreciable decrease in nitrogen.

It is interesting to carry farther this inquiry in relation to the decrease of plant-food, and ascertain in what grades of fertilizers the changes are most noticeable. If we classify complete commercial fertilizers on the basis of the total amount of plant-food in 100 pounds of fertilizer into four classes, we can show the varying proportion of these classes year by year. For this purpose we divide fertilizers into the following four classes: (1) Those containing less than 10 per cent of plant-food; (2) those containing between 10 and 12 per cent; (3) those containing between 12 and 15 per cent; and (4) those containing over 15 per cent. The results are tabulated below.

TABLE III.— DISTRIBUTION OF FERTILIZERS ACCORDING TO CONTENT OF PLANT-FOOD.

YEAR.	AVERAGE NUMBER OF FERTILIZERS PER 100 IN			
	Class I containing less than 10 percent of plant-food.	Class II containing between 10 and 12 percent of plant-food.	Class III containing between 12 and 15 percent of plant-food.	Class IV containing more than 15 percent of plant-food.
1914.......	1.0	9.7	30.1	59.2
1915.......	2.8	14.3	49.4	33.5
1916.......	3.1	36.9	54.7	5.3
1917.......	8.2	33.3	53.4	5.1
1918.......	10.2	43.0	44.0	2.8
1919.......	10.6	36.7	46.2	6.5

Inspection of Table III shows that the number of low-grade fertilizers (those containing less than 10 per cent of plant-food) increased steadily from 1 per 100 in 1914 to nearly 11 in 1919; that the proportion of fertilizers in Class II (containing 10 to 12 per cent of plant-food) increased from about 10 per 100 in 1914 to over 40 in 1918; that the number of those in Class III (containing 12 to 15 per cent of plant-food) increased from 30 per 100 in 1914 to about 55 in 1916, and then decreased somewhat; that the number of fertilizers in Class IV (those containing over 15 per cent of plant-food) decreased from 59 per 100 in 1914 to 33.5 in 1915, to 5.3 in 1916, and to 2.8 in 1918. These facts, briefly summarized, mean that the proportion of high-grade commercial fertilizers decreased rapidly after 1914 and 1915, while the proportion of lower-grade mixtures increased markedly.

RETAIL PRICES OF COMPLETE FERTILIZERS

In Table IV we give for each year the average selling price of one ton of complete fertilizer, the number of pounds of plant-food per ton, the average cost of one pound of plant-food, and the relative cost based on the cost in 1914.

TABLE IV.— COST OF PLANT-FOOD IN FERTILIZERS.

YEAR.	Average retail price per ton of fertilizer.	Amounts of plant-food in one ton.	Average retail price of one pound of plant-food.	Relative cost of one pound of plant-food.
		Pounds	Cents	
1914.............	$28.53	324.8	8.8	100
1915.............	30.87	278.6	11.1	126
1916.............	35.00	254.8	13.7	155
1917.............	34.40	252.4	13.6	154
1918.............	47.70	241.8	19.7	224
1919.............	80.22	244.0	33.1	376

An examination of the figures in Table IV shows: (1) That the selling-price of fertilizers increased gradually thru 1917, then in 1918 there was a marked advance, and then in 1919 a great upward leap; (2) That, while there was increase in the ton price, there was at the same time a marked decrease in the amount of plant-food per ton, and therefore the only proper basis of yearly comparison is the price of plant-food per pound as shown in the fourth column of Table IV, in which we see that the cost of one pound of plant-food increased from 8.8 cents in 1914 to 33.1 cents in 1919; (3) That, taking the cost of one pound of plant-food in 1914 as 100, the relative increase year by year is shown in the last column of Table IV. The results show that in 1915 there was an advance of 25 per cent; in 1916 and 1917, about 55 per cent; in 1918, 225 per cent, and in 1919, 376 per cent. Therefore, during the year of 1919 the average cost of plant-food in complete fertilizers was nearly four times what it was in 1914.

ACID PHOSPHATE

In Table V there are given data relating to the composition and retail cost of acid phosphate during the war period.

TABLE V.— AMOUNT AND COST OF AVAILABLE PHOSPHORIC ACID IN ACID PHOSPHATE.

YEAR.	Available phosphoric acid.	Retail price per ton.	Retail cost of one pound of available phosphoric acid.	Relative cost of one pound of available phosphoric acid.
	Per ct.		Cents	
1914.............	14.65	$14.50	4.9	100
1915.............	15.23	14.60	4.9	100
1916.............	15.00	20.20	6.7	140
1917.............	15.07	19.16	6.3	130
1918.............	15.00	25.30	8.4	170
1919.............	15.52	30.00	9.7	200

The average composition of acid phosphate, while varying somewhat, generally kept in the neighborhood of 15 percent of available phosphoric acid. The average price per ton varied from $14.50 in 1914 to $30.00 in 1919. The average retail price of one pound of available phosphoric acid varied from 4.9 cents in 1914 to 9.7 cents in 1919, practically doubling during the war period.

NITRATE OF SODA

In Table VI we give the data bearing on the composition and cost of nitrate of soda during the years 1914 to 1919.

TABLE VI.— AMOUNT AND COST OF NITROGEN IN NITRATE OF SODA.

YEAR.	Nitrogen.	Retail cost per ton.	Retail cost of one pound of nitrogen.	Relative cost of one pound of nitrogen.
	Per ct.		Cents	
1914.............	15.20	$54.25	17.8	100
1915.............	15.25	50.25	16.5	....
1916.............	15.50	77.62	25.0	140
1917.............	15.36	77.50	25.2	140
1918.............	15.38	114.50	37.2	210
1919.............	15.24	116.80	38.3	215

The chief point of interest, indicated by the data in Table VI, is that the price of nitrogen in nitrate of soda more than doubled between 1914 and 1918.

BONE

Table VII gives the composition of bone and the retail cost per ton as well as the cost of one pound of plant-food constituents.

TABLE VII.— AMOUNT AND COST OF PLANT-FOOD CONSTITUENTS IN BONE.

YEAR.	Nitrogen.	Total phosphoric acid.	Retail cost per ton.	Plant-food in one ton.	Retail cost of one pound of plant-food.	Relative annual cost of one pound of plant-food.
	Per ct.	Per ct.		Lbs.	Cents	
1914........	3.12	23.30	$36.60	528.4	7.0	100
1915........	3.03	23.50	35.10	530.6	6.6	....
1916........	2.97	23.64	42.06	512.2	8.2	117
1917........	3.10	22.86	45.20	519.2	8.7	124
1918........	2.95	23.20	52.97	523.0	10.1	144
1919........	2.90	24.58	60.80	549.6	11.1	157

The data show that, while the retail cost of bone advanced after 1915, the cost of one pound of plant-food did not increase relatively from year to year as much as in the case of mixed fertilizers, acid phosphate and nitrate of soda.

COMMERCIAL DRIED ANIMAL MANURES

For some years there has been a considerable sale of dried pulverized animal excreta, such as sheep, cattle and pig manure. On account of the potash content, there has been an increased demand

TABLE VIII.—AMOUNT AND COST OF PLANT-FOOD IN DRIED ANIMAL MANURES

YEAR.	Nitrogen.	Phosphoric acid.	Potash.	Retail cost per ton.	Plant-food in one ton.	Retail cost of one pound plant-food.	Relative annual cost of one pound of plant-food.
	Per ct.	Per ct.	Per ct.		Lbs.	Cents	
1914...	2.23	1.56	2.31	$37.17	122.0	30.5	100
1915...	2.17	2.04	2.32	43.33	130.6	33.2	109
1916...	2.07	1.42	1.60	35.60	101.8	35.0	115
1917...	1.96	1.65	1.81	35.10	108.4	34.5	113
1918...	2.02	2.27	1.88	48.10	123.4	39.0	128
1919...	2.15	1.81	2.21	55.63	123.4	45.1	148

for these materials. We, therefore, present data relating to their composition and cost.

In regard to composition, these materials vary considerably, especially in the percentage of phosphoric acid and of potash. The cost of plant-food increased from year to year since 1914, but the increase was not so great, proportionately, as in the case of the other plant-foods previously considered, but this was due to the fact that the cost was relatively high at the beginning of our period of comparison. As compared with plant-food in complete mixed commercial fertilizers, the plant-food in these dried animal manures is high. The cost of one pound of plant-food in the animal manures has averaged in the different years from 1.5 to 3.5 times as much as in the case of the mixed fertilizers.

THE CARBON DIOXIDE CONTENT AS A BASIS FOR DISTINGUISHING HEATED FROM UNHEATED MILK*

L. L. VAN SLYKE AND R. F. KEELER

SUMMARY

This investigation has had for its object to learn whether the heating of milk under the conditions used in pasteurization changes the CO_2 content of the milk in such a way as to make it a means of knowing whether milk has been pasteurized or not. It has been necessary, therefore, to study such other conditions as may affect the CO_2 content in the usual method of handling milk from the time of milking to the time of delivery to the consumer.

It is found that the CO_2 content of milk is not appreciably affected by the method of milking; that the CO_2 content rarely drops below 3 to 3.5 per cent by volume, when milk stands under ordinary conditions, even for periods of 20 to 40 hours after milking; that the CO_2 content is not appreciably changed by passing thru a separator, and that only extreme and prolonged stirring reduces the CO_2 below 3 per cent by volume; and that heating milk under the conditions required for pasteurization reduces the CO_2 content to, and usually below, 2.5 per cent by volume.

Therefore, it is believed that, when the percentage of CO_2 by volume is not more than 2.5, it is safe, in general, to assume that the milk has been heated to the temperature of pasteurization.

INTRODUCTION

It has been pointed out in Technical Bulletin No. 69 of this Station that the heating of milk in the process of pasteurization reduces the CO_2 content to such an extent that this change might be made the basis of a method for distinguishing pasteurized from unheated milk. In order to ascertain whether this fact of decrease of CO_2 could be utilized in the development of such a method, it is necessary to learn to what extent the CO_2 content of normal milk is reduced under a variety of conditions, especially such conditions as are associated with the handling of milk from the udder to delivery to

* Reprint of Technical Bulletin No. 78, March, 1920.

consumers. A study has been made, therefore, of the effect of such conditions as (1) the method of milking, (2) the length of time of standing of milk after being drawn from the udder (3) the effect of agitation, and (4) the effect of temperature. The results of this work are presented in the pages following.

The details of the method used in the determination of CO_2 in milk are explained in the bulletin mentioned above.

EXPERIMENTAL PART

When the milk is drawn from the udder and exposed to the air, a considerable proportion of its CO_2 escapes. The amount of CO_2 usually present in normal milk in the udder has been found in the former work, to which reference has already been made, to average about 10 per cent by volume. As a result of our work here given we find that immediately after milk is drawn from the udder, the CO_2 content is generally less than one-half of this figure, varying between 4 and 5 per cent in most cases.

It is our purpose now to give the detailed results of our work, showing to what extent different conditions affect the CO_2 content of milk after leaving the udder.

I. EFFECT OF METHOD OF MILKING

A few determinations of CO_2 were made in the case of milk drawn from the udder by hand in comparison with that drawn by milking machine, two different kinds of machines being used. No appreciable difference was found in all of the samples examined by us, the results all varying only between 4 and 4.5 per cent of CO_2 by volume, without reference to the method of milking.

II. EFFECT OF STANDING

Numerous examinations have been made by us to ascertain the amount of CO_2 in milk at different intervals after milking, when kept under ordinary conditions. Milk from individual cows and also from herds was used. After being drawn from the udder, the milk was kept under conditions involving a minimum amount of handling or agitation.

In the case of samples of herd milk, obtained at a local milk station, the milk had been transported several miles directly from the farms to the station. The transportation was, of course, accompanied by more or less agitation. We examined forty such samples at intervals of 8, 20, and in some cases, 40 hours after milking. The results are summarized in the following table.

TABLE I.—CO_2 IN HERD MILK AT INTERVALS AFTER MILKING.

CO_2 IN SAMPLES, PERCENT BY VOLUME.	NO. OF SAMPLES EXAMINED AFTER		
	8 hrs.	20 hrs.	40 hrs.
3.0	0	3	2
3.5	12	5	3
4.0	16	17	6
4.5	7	9	2
5.0	3	4	1
5.5	2	2	0

These results indicate that, under the conditions existing, the volume per cent of CO_2 in no case falls below 3, even 40 hours after milking, and only in a few cases below 3.5 per cent after 20 hours or more.

In the case of milk drawn separately from five individual cows in our Station herd, and examined, after standing without further handling, at intervals of 18, 42, 64, and 90 hours, the amount of CO_2 present in the milk soon after being drawn decreased by 0.5 to 1.0 per cent by volume in 18 hours, and 1.0 to 1.5 per cent in 42 hours, after which there was no further decrease. The percentage of CO_2 in the fresh milk varied from 4 to 4.5 in the different milks and this dropped to a minimum of 3 per cent, no further decrease taking place after 42 hours.

In the case of the mixed milk of our Station herd, which contained 4 per cent by volume of CO_2 3 or 4 hours after milking, it was found, after standing 6 hours more, to contain 3.5 per cent, a decrease of 0.5 per cent.

III. EFFECT OF AGITATION

Several experiments were made to ascertain the effect of agitation in different forms upon the CO_2 content of milk. Milk was passed thru a separator in some cases, and in others was stirred by special apparatus.

In the case of milk passed thru a cream-separator, the milk before separation contained 4 per cent by volume of CO_2. The resulting skim-milk was found to contain the same amount of CO_2, while the cream contained 3 per cent. In the case of another sample of milk, containing 3.5 per cent of CO_2 by volume before separation, the resulting skim-milk contained the same percentage of CO_2. Skim-milk containing 4 per cent by volume of CO_2 was found after being passed thru a separator to lose no CO_2.

In experiments in which the milk was stirred, the agitation was produced by means of the stirring-apparatus described in Technical Bulletin No. 65 of this Station.

In the case of a sample of milk containing 4 per cent of CO_2 by volume, the milk was kept at room temperature (about 70° F.) during the stirring and examinations were made at stated intervals, with the following results:

Length of time of stirring:	0	15 min.	30 min.	45 min.	1 hr.	2 hrs.	6 hrs.
Per cent of CO_2 by volume:	4	3.5	3	3	3	2.5	2

From these results, it would appear that such agitation as milk is subjected to in the methods commonly employed in handling milk on farms and before being placed on the market has little or no effect in reducing the percentage of CO_2.

IV. EFFECT OF HEATING

Experiments were made for the purpose of ascertaining the effect of heat upon the CO_2 content of milk, using different temperatures and in some cases combining heat and agitation. The special object in mind was to find out the effect of those conditions commonly used in pasteurizing milk.

In the case of milk pasteurized by the "flash" system, samples containing 4 per cent of CO_2 by volume were found after pasteurization to contain not more than 2 per cent.

Numerous samples of market milk, pasteurized at 143° F. and bottled, were examined 30 to 36 hours after pasteurization and found to contain 1.5 to 2 per cent of CO_2 by volume.

Milk heated at 143° F. for 30 minutes was examined before and after being subsequently cooled to 42° F. The amount of CO_2 found was the same in both cases, 2 per cent.

Fresh milk containing 4 per cent of CO_2 by volume was heated at 145° F. without agitation, for different periods of time, with the following results:

Minutes heated:	2	3	4	5	10	12	20	30
Per cent of CO_2 by volume:	3.5	3.0	2.5	2.5	2.5	2.5	2.5	2.5

A sample of milk after being heated for 30 minutes at 172° F. without stirring was found to contain 2.5 per cent of CO_2 by volume. Another sample heated at 143° F. with stirring for 30 minutes lost all of its CO_2.

By the methods of pasteurization commonly employed, pasteurized milk, as found in the market by us, seldom contains more than 2.5 per cent of CO_2 by volume and usually contains less.

DISTINCTION BETWEEN HEATED AND UNHEATED MILK

Taking into consideration all the results of our work, it appears that, under the conditions to which normal unheated milk is subjected in its handling from the time of milking to the time of delivery to the consumer, the percentage of CO_2 by volume rarely, if ever,

drops below 3 and seldom below 3.5, while subjection of the milk to the conditions of heating used in pasteurization reduces the percentage of CO_2 by volume to 2.5 or less. Therefore, it appears safe, in general, to assume that milk containing less than 2.5 or 3 per cent of CO_2 by volume has been heated to the temperature of pasteurization.

REPORT

OF THE

Department of Entomology

P. J. PARROTT, *Chief in Research (Entomology).*

HUGH GLASGOW, *Associate in Research (Entomology).*

R. D. OLMSTEAD, *Assistant in Research (Entomology).*

C. R. PHIPPS, *Assistant in Research (Entomology).*

G. F. MACLEOD, *Assistant in Research (Entomology).*

F. Z. HARTZELL, *Associate in Research (Entomology).*
(Connected with Grape Culture Investigations.)

TABLE OF CONTENTS

REPORT OF THE DEPARTMENT OF ENTOMOLOGY

INSECT INJURIES IN RELATION TO APPLE GRADING *

B. B. FULTON†

SUMMARY

The species of insects that attack apple fruits are described and grouped according to the character of the injuries they produce.

A key for the identification of the different species is included, and permits ready recognition of the typical malformations of the fruits.

Annual losses caused by some species of insects are large, and the aggregate damage by minor forms assumes considerable proportions. Important as are the insects as factors in crop standardization, their economic status rests largely on their destructive influence on crop production.

Methods for combating the individual insects are indicated. In the main, the destructive agents are efficiently and economically treated by a routine system of spraying for which directions are given.

INTRODUCTION

In the practice of grading fruit according to the provisions of the New York Apple Grading Law the attention of the fruit grower has quite naturally been called to the great variety and diverse character of the insect injuries appearing on the fruit at picking time. This has led to an unusual number of demands on the Station for information in regard to the agents responsible for blemishes on the mature apples. The orchardist can readily see the value of greater knowledge on his part concerning the distinguishing marks of the various insect injuries, which are, in many cases, quite characteristic and often more conspicuous than the insect itself. It is the purpose of this bulletin to make such identification as easy and rapid as possible, and to show where there is danger of confusion of the causal agents.

---

* Reprint of Bulletin No. 475, May, 1920.

† Formerly Assistant Entomologist of this Station and now connected with the Oregon Agricultural Experiment Station, Corvallis, Oregon.

When the grower has once learned to recognize the various defects, he can easily tell which insects are least under control in his orchard, and can modify his spraying practices accordingly. Since the better classes of graded fruit are more valuable it is important to reduce the number of blemished apples to the lowest percentage possible. The New York Standard Fancy Grade permits no more than 5 per cent of all defects of color, shape, dirt, and insect or fungus injury, nor more than 2 per cent of any single defect. The Standard A and B grades have limits of 10 and 15 per cent, respectively, for all defects combined, and 5 per cent on any single defect. In order to successfully pack apples in these grades it is obvious that the standard of quality for the whole orchard must be high.

In this bulletin only those insects are considered which attack the fruit itself, altho the extent of this injury is not always a measure of the damage caused by a particular species. Many serious pests do not work on the fruit at all. There are some insects which destroy more fruit than is apparent from the results at picking time, as for example, bud moth larvæ and leaf rollers which cause many of the young fruits to drop so that evidence of the injury is not present later in the season.

METHODS

During the summer of 1917, experiments were conducted to establish beyond doubt the identity of various types of injuries found on apples at picking time. To accomplish this, light cages were constructed which could be attached to a fruit spur. (See Fig. 20.) By this method one insect could be confined to a cluster of fruit without contamination by other species so that the agent responsible for the injury could be determined. Fruit clusters were examined carefully before being used so that only perfect specimens would enter into the experiment. The cages remained on the trees until the injury developed characters which could not be confused with any other, after which they were removed, leaving the tags for identification attached to the tree until the fruits matured and were harvested.

Fig. 20.— Wire Cage in Place Ready for Bag.

The cages were made as follows: Two copper wires of No. 16 gage, about two feet long were twisted together tightly at the middle, the ends spread at right angles to each other, and curved around as if enclosing a ball. The tips were bent so as to run parallel for about two inches. The frame was then fitted around the fruit cluster and the straight ends of the wires fastened to the twig, after first padding it with a layer of cotton. If the frames are made so that one wire will be a few inches longer, this end can be used to wind around the others to hold the frame in place. After the insect was placed on the cluster a gauze bag, preferably black in color, was slipped over the frame and tied at the base. For this purpose, a silk material known as mousseline de soie was used at first, but later a cotton crinoline with an open weave was adopted. Pieces of the material twice as long as the desired width of the bag were cut, folded once, and seamed along the other two sides with a sewing machine. By this method a quantity of the bags could be made easily and quickly.

Another series of experiments consisted in making various mechanical injuries on the fruit, in a manner similar to the work of certain insects. These consisted of pin pricks, deep and shallow cavities, and holes about 1 mm. in diameter drilled into the flesh. The injuries were made at intervals of two weeks. It was most interesting to note the similarity of development between the imitation worm holes and those made by the insects themselves at the same time. The early wounds resulted in a different kind of a scar from that following later injuries and both types corresponded to early and late injuries, respectively, by caterpillars.

KEY FOR IDENTIFICATION OF INSECT INJURIES TO MATURE APPLES[1]

PAGE

A. Burrows in the interior of the fruit or mines beneath the surface.

1. With a cavity about the core or a small burrow leading toward the core; often with some surface feeding or mining around the entrance hole.
   Codling moth 362

[1] Further description of the injuries may be found on the pages indicated.

PAGE

2. Feeding cavity usually an irregular blotch mine just beneath the skin; a few winding tunnels deeper in the flesh.
   - Lesser apple worm 364
   - Oriental fruit moth 365
3. With numerous winding brown streaks and burrows of small size in all parts of the flesh.
   - Apple maggot 366

B. Scars or open cavities, having a smooth "russeted" surface or a scaly, corky surface; usually accompanied by more or less distortion of the fruit.

1. Pale brown semicircular or round scars, $\frac{1}{2}$ inch and smaller, situated in a depression or sometimes protruding; when numerous fruit is knotty.
   - Plum curculio (early oviposition and feeding punctures) 375
2. Pale brown, smooth scars with thin, scattered, dark brown scales; usually in a depression or pit.
   - Green fruit-worms, leaf rollers, and other early apple worms 368
3. Scars and open cavities with a thick hard surface, which is often broken up into dark brown corky scales.
   a. Mostly shallow excavations.
      - Oblique-banded leaf-roller, 2nd brood.... 371
      - White-marked tussock-moth 371
   b. Deep, irregular pits.
      - Rose chafer 379
4. Circular scars, depressed in center, $\frac{1}{8}$ to $\frac{1}{4}$ inch diameter.
   - Casebearers (early feeding punctures), uncommon 380

C. Holes or open cavities, made in nearly mature fruit; flesh where exposed, dried, but not hard or corky; no distortion of fruit.

1. Shallow holes or areas of surface feeding, usually under leaf fastened to fruit.
   - Bud moth 372
   - Oblique-banded leaf-roller, 2nd brood.... 371

PAGE

2. Hole accompanied by more or less mining under the surface.
   Codling moth (late individual) 362
3. Round holes $\frac{1}{16}$ inch to $\frac{1}{8}$ inch wide leading into a rounded cavity somewhat larger than the opening.
   Plum curculio (late feeding punctures) .. 375
4. Small round holes, less than $\frac{1}{16}$ inch wide, leading into a small shallow cavity under the skin.
   Casebearers 380

D. Dimples or funnel-shaped pits in the surface of fruit.
1. With a brown scar at the bottom.
   a. Irregular depressions; scars rounded or semicircular.
      Plum curculio (early feeding punctures).. 375
   b. Symmetrical funnel-shaped pits with small round scar. A section cut thru center of pit shows a dark hardened line leading toward center of apple.
      Apple curculio 376
2. Funnel-shaped pits or depressions, usually without scars but sometimes with irregular spreading russeted areas.
   Red bug 373
3. Slight dimples or depressions with a minute black speck in the center; sometimes depression is lacking.
   a. Flesh of apple with winding brown streaks or burrows.
      Apple maggot (egg punctures) 366
   b. With a thin line of hardened tissue leading from black speck to core; seed beneath containing a maggot.
      Apple-seed chalcid 381

E. Round red spots with flat gray scales in center.
   San Jose scale 378

F. Small cluster apples wrinkled at calyx end.
   Rosy apple aphis 377

DESCRIPTION OF INSECT INJURIES AND THEIR PREVENTION

CODLING MOTH

(*Carpocapsa pomonella* Linn.)

The larva of the codling moth is by far the most destructive enemy of the apple and is the common cause of wormy fruit. There are two broods of the insect during the summer and larvæ may be found at any time after the fruit is about three weeks old.

Injury.—Externally the injury by this insect appears as the entrance hole of the newly hatched worm or as the exit hole of the mature larva. The worm spends most of its life feeding upon the core and seeds, so that the interior of a wormy apple shows a large cavity partly filled with small pellets of brown excrement loosely fastened together by a web. The majority of the spring brood enter the closed calyx cup and after feeding a little within the cavity begin to tunnel toward the core. (See Fig. 21, *b*.) The only external evidence of such an entrance appears in the form of masses of brownish excrement protruding from the blossom end of the apple.

Fig. 21.—Codling Moth: *a*, Exit Hole; *b*, Entrance Hole in Calyx; *c*, Side Entrance.

Part of the larvæ of the first brood and the majority of the second brood enter at some point other than the calyx cup. This may be beside the stem or in the hollow part of the apple just outside of the calyx lobes. Entrances in the side of the apple are very common and the larvæ seem to prefer to start feeding in some blemish or scar on the surface of the fruit or at a point of contact with a leaf or another apple. Sometimes the worm dies after gaining an entrance so that the only injury is a tiny hole with a small discolored area surrounding it, commonly known as a sting. Before tunneling to the core the second brood larvæ generally spend some time feeding on the surface, or mining just beneath the skin. The

effect is often conspicuous, especially on pale colored apples, on account of the surrounding reddish discolored area. (See Fig. 21, *c* and Plate II, fig. 1.)

The most noticeable injury caused by the codling moth is the large exit hole (Fig. 21, *a*) which is formed by the mature worm usually in the side of the apple. This remains for a time plugged near the surface by a loose mass of excrement, which is forced out by the larva when it leaves the apple to spin its cocoon.

The most characteristic feature of codling moth work is the large feeding cavity in the core. In the case of entrance holes where the larvæ have died it is harder to be sure of the causal agent. Small "stings" can usually be distinguished by the minute size of the entrance holes. Entrance holes differ from late casebearer work, which is rare, by the irregular course of the larvæ in the flesh instead of a shallow mine immediately surrounding the hole; and are unlike late curculio feeding punctures, which always have a symmetrical rounded cavity just beneath the surface. Second brood larvæ feeding under a leaf or between two apples may cause an injury very similar to the later work of the bud moth or oblique-banded leaf-roller; but it is usually confined to a small area and is mostly, or in part, mining beneath the skin. Egg puncture scars caused by apple maggot may resemble small "stings" but the characteristic tunnels in the flesh usually permit accurate identification of this pest.

Control.— The codling moth is most efficiently combated by spraying with an arsenical as petals drop so as to fill the calyx cups with poison. A large percentage of the worms gain entrance into apples thru the blossom end and it is necessary to get the poison inside before the calyx lobes close. If the orchard is large it may be necessary to commence spraying when two-thirds of the petals have fallen in order to complete the application before the calyx lobes form a tight roof over the cavity. All trees, whether carrying a crop or not, should be sprayed at this time. Failure to secure satisfactory control is usually due to the lack of careful spraying or of too sparing use of spraying materials.

A second spraying is sometimes made two to four weeks later. The earlier application is advisable if weather conditions are right for infection by apple scab, but for codling moth the latter date is usually best. The actual time for most efficient control varies with the season. Moths emerge shortly after the calyx stage but

are not likely to deposit eggs until there is an evening temperature of 60° F. or higher at eight o'clock. The spray should be applied following an evening at this temperature.

To determine the time of spraying for the second brood of codling moth a burlap band may be tied around a tree trunk to allow the larvæ to pupate under it. During the latter part of July this should be examined every few days, and when empty pupal cases are found within the newly formed cocoons it indicates that the moths have emerged and the time for spraying is at hand. If there is any uncertainty as to the proper time for spraying it is best to keep a coating of lead arsenate on the fruit, but during average seasons one application during midsummer, either late in July or early August, is sufficient.

LESSER APPLE WORM

(*Enarmonia prunivora* Walsh)

In most localities the lesser apple worm does not occur in very large numbers. The first larvæ appear at about the same time as those of the codling moth, and in the North there are two generations annually.

FIG 22.— LESSER APPLE WORM.

Injury.— Like the codling moth, most of the first brood larvæ start feeding around the calyx or the stem, while later in the season more of them work at the side of the apple. Altho the injury by this insect resembles that of the codling moth, typical cases can be readily determined by the fact that most of the feeding is done near the surface, instead of around the core. The winding movement of the larvæ while feeding results in an irregular cavity just beneath the skin with a few rambling tunnels going deeper into the flesh and sometimes even reaching the core. (See Fig. 22 and Plate II, fig. 2, *b*.) Externally, it appears as an irregular, pale-colored blotch, conspicuous when on the side of the apple, but which might easily escape notice when occurring around the calyx or stem. The skin eventually becomes wrinkled and sometimes breaks open.

Apple maggot injury differs from this in being more scattered thruout the flesh and can also be distinguished by the numerous small brown corky areas.

Control.— The applications suggested for combating the codling moth are also applicable to the lesser apple worm.

ORIENTAL FRUIT MOTH

(*Laspeyresia molesta* Busck)

The oriental fruit moth is a pest of recent introduction which is known to occur in the southeastern corner of the State. The larvæ feed on the twigs and fruit of the peach and other common orchard

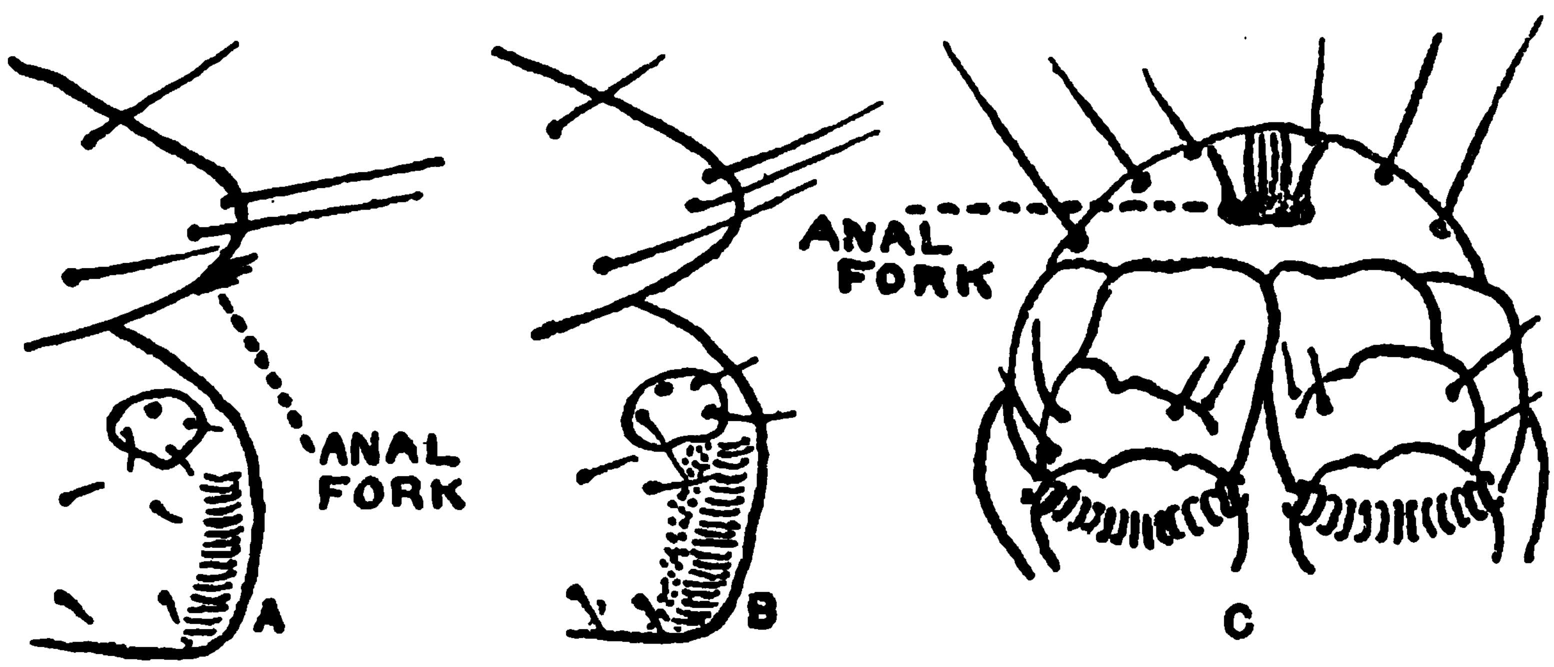


FIG. 23.—LATERAL VIEW OF ANAL SEGMENT OF LESSER APPLE WORM (*a*) AND CODLING MOTH (*b*). (AFTER P. GARMAN.) VENTRAL VIEW OF ANAL SEGMENT OF ORIENTAL FRUIT MOTH (*c*). (AFTER WOOD AND SELKREGG.)

fruits. On the apple the twig injury is slight, but it attacks the fruit almost as readily as it does the peach.

Injury.— According to Garman[1] the injury to the apple is almost indistinguishable from that caused by the lesser apple worm. " Injury to the exterior of the apple resembles that of the lesser apple worm, but the burrows within are usually more extensive and winding. The burrow never extends straight thru the core like that of the codling moth nor do the larvæ usually feed upon the seeds." The larvæ of this insect and the lesser apple worm both have anal forks which distinguish them from the larvæ of the codling moth. (See Fig. 23.)

Control.— No practical method for controlling this insect in commercial orchards has been devised. Arsenical sprays afford only

[1] Maryland Agr. Exp. Sta. Bul. 223, 104. 1918.

slight protection, since the larvæ feed largely within twigs and fruit. The immunity of the species to common repressive and remedial measures has stimulated serious efforts to discover effective measures of protecting fruit plantings.

APPLE MAGGOT

(*Rhagoletis pomonella* Walsh)

The apple maggot is of minor importance in most localities, but in some regions in this State, especially where orchards are not regularly sprayed, it has at times become a pest of prime importance and has been known to take the entire crop of an orchard. The insect attacks mainly summer and fall varieties of apple, particularly those which are sweet or sub-acid. The adult flies appear late in June or early in July and are present thruout the summer. Maggots may be found any time after the middle of July.

FIG. 24.— APPLE MAGGOT: *a*, EGG PUNCTURE.

Injury.— The tiny young maggots burrow long, winding channels thru the flesh of the apple (Fig. 24) and remain small until the fruit begins to ripen, when they commence to grow rapidly and increase the size of their burrows. They soon destroy large portions of the flesh and sometimes the whole interior of the apple becomes a rotten mass. (See Plate II, fig. 3.)

Occasionally, there is almost no external sign of work of the apple maggot except some scattered brownish specks where the skin of the apple was punctured by the adult fly while depositing eggs. (See Fig 24, *a*.) These tiny spots are usually in a slight depression and sometimes have a white waxy substance over them. Ordinarily, the surface of the apple shows brown irregular areas or winding streaks where it has been undermined by the maggots. Often the work of the young maggots near the skin of the growing apple will result in a fruit with a bumpy surface. Affected apples tend to drop prematurely.

If the apple is cut it will show numerous, small, brownish, corky spots or streaks, caused by the tiny burrows of the young maggots. In nearly ripe fruit, there are also larger holes in the flesh and the maggots themselves may be visible. These characters distinguish the work from that of other insects; but there is a disease known by various names, such as bitter pit, Baldwin spot, cork, and dry rot, which might be confused with the work of the maggot before the latter has begun its final growth. The disease usually shows on the surface as small, nearly circular sunken areas which are fairly uniform in shape and size. (See Fig 36, *g*.) In the flesh there are brownish corky areas but no holes or winding tunnels. The oviposition scars on the surface will also distinguish the work of the apple maggot from bitter pit.

Control.— Neglected orchards, particularly of summer and fall varieties of apples, are susceptible to losses every year. This is especially true in localities where little attention is given to fruit-growing and low standards of orchard management prevail. Formerly efforts to combat the pest were largely directed to the destruction of the wind-falls, which was often accomplished by pasturing the orchard with hogs and sheep. Recently the use of arsenicals has been recommended for the destruction of the fly.[1] The freedom of commercial apple orchards in western New York from important injuries by the insect is believed to be due to the system of spraying that is generally practised.

To protect the apple crop from maggots, chief reliance should be placed on the use of 2 or 3 pounds of the paste arsenate of lead or 1 to 1.5 pounds of the powdered form of this arsenical to 50 gallons of spraying mixture. The first application should be made as the adults begin to appear, either late in June or early in July, while a second treatment should follow in from two to three weeks. In very wet seasons a third application, about ten days after the second spraying, will be necessary. In determining the time when the flies first appear, it is not considered safe to wait until they are seen in the orchard. Considerable damage can be done by the pests before the creatures may be observed in appreciable numbers about the trees. The time of the first emergence of the insects should,

[1] Brittain, W. H. and Good, C. A. Nova Scotia Dept. Agr. Bul. 9, 1–70. 1917.
Caesar, L. and Ross, W. A. Ontario Dept. Agr. Fruit Branch Bul. 271, 1–32. 1919.
Herrick, G. W. Cornell Univ. Agr. Exp. Sta. Bul. 402. 1920.

if possible, be determined by breeding cages, and it is here that the local spraying expert can render invaluable service. It is believed that two years should almost completely destroy the insect in any orchard, provided infested orchards are not situated close by. In such case every effort should be made to have these treated also. In all orchards, every tree, whether bearing fruit or not, should be sprayed because the adults often frequent such trees until egg-laying begins. Heavy rather than light applications of the mixture should be made, especially if only two are given, because adults continue to emerge for a period of six weeks or more, and the poison should remain on the trees to kill them before they can lay their eggs. Heavy applications remain on longer than light applications.

EARLY APPLE WORMS

A characteristic form of injury results from the feeding of caterpillars which work outside of the fruit, eating deep holes or shallow cavities. For convenience these have been divided into two groups, the early-feeding worms and the late-feeding worms. No sharp distinction can be drawn between the two because the injuries may be caused at any time during the summer, but a hole produced in a small rapidly growing fruit will leave an entirely different scar from one made in an apple that is nearly full grown. There are several common species of caterpillars that hatch in the spring and feed upon the leaves and young fruit. They often eat deep holes in the side of the apples, sometimes going as deep as the core and in rare instances tunneling completely thru. A large percentage of the injured apples drop off, but if they are not too severely injured the wound will heal over and form a new skin. When the fruit is mature the injury appears as a brownish scar with the surface slightly roughened or "russeted" and more or less covered with fine corky scales which are the remains of the original callus formed soon after the wound was made. (See Fig. 25 and Plate II, fig. 6, *b*.) However, it does not bear the thick,

FIG. 25.—EARLY APPLE WORMS.

corky coating which forms on wounds made later in the summer. The scar is usually situated in a depression in the fruit, but sometimes, especially if small, it is distinctly elevated above the general surface. Deep or widespread injuries may cause distortion of the fruit.

Several types of injury might be confused with these scars, including scab, frost, spray, or mechanical injury, and late fruit worm scars. An early infection by apple scab fungus leaves a scar similar to that described above except that it has a dark, sooty appearance. (See Fig. 36, *f* and Plate II, fig. 6, *a*.) On the old scars small patches or scales of dark olive or sooty color are separated by narrow, sunken lines of light brown. If the disease was severe the fruit will be distorted and cracked. Late frosts sometimes cause russeted bands around the apples. (See Fig. 36, *c*.) Spray injuries leave a rough scar but there is no definite edge or boundary between the injured part and the rest of the surface. (See Fig. 36, *d*.) Mechanical injury or hail pecks may leave a corky surface of dark sunken area, but here again it is not precisely limited. (See Fig. 36, *a* and *b*.) The work of the late apple worms will be described under that head.

GREEN FRUIT-WORMS

(*Graphiphora alia* Guenée, *Xylina antennata* Walker, *X. laticinerea* Grote, *X. grotei* Riley)

Among the most important of the early apple feeders are several species of medium sized, green, hairless, caterpillars, which hatch just before blossom time and feed on the leaves and young fruit. In June they attain full size and pupate. The moths emerge in the fall or following spring. (See Plate I, fig. 7.)

Injury.—These insects are probably most commonly responsible for the early apple worm injury previously described. Fruit worms are apt to appear on the trees in moderate numbers every year, while the fruit-tree leaf-roller, which produces the same type of injury, is more spasmodic in its occurrence.

Control.—In general, the sprays applied before and after blossoming are the most important for the control of these insects. If infestation is severe the blossom-pink spray should be put on close to blossoming time and should be applied thoroly, using at least 6 pounds of lead arsenate to 100 gallons of the spraying mixture.

The use of a spray gun at high pressure will result, to a large measure, in mechanical control by causing the young worms to drop from the trees.

FRUIT-TREE LEAF-ROLLER

(*Archips argyrospila* Walker)

The fruit-tree leaf-roller in some localities and in some seasons causes greater loss than the codling moth, but ordinarily it is content with putting scars on a small percentage of the crop. There is but a single brood annually.

Injury.— The slender, active, green caterpillars normally feed on the leaves by rolling them up or tying them together with a web. When a leaf comes in contact with a young fruit, they will often eat holes in the latter. (See Plate I, fig. 8.) The work of the leaf-roller is similar to that of the green fruit-worm but on the average it probably causes a little greater distortion by feeding on smaller fruits.

Control.— The ordinary spraying practices do not give effective control when this insect becomes abundant. The best known means of control is a dormant spray in spring using miscible oil and water (6 to 100) or a 10 per cent kerosene emulsion. Oil sprays kill most of the eggs that are hit, and all parts of the tree should be covered, including the main branches and trunk. The oil application is less likely to injure the tree if delayed as near the hatching time as possible, but not later than the delayed dormant stage shown in the spray schedule. (See Plate III.) A period of fair weather for several days following spraying is very important for good control.

If the egg spray has been omitted some control may be gained by adding lead arsenate to the delayed dormant and following this with an additional application of the arsenical at the rate of 6 pounds to 100 gallons of the spraying mixture when the blossom buds in the cluster begin to separate.

OTHER EARLY APPLE WORMS

Altho the species of green fruit-worms and the fruit-tree leaf-roller are the most important insects which eat holes in the young fruit, there are many other leaf-feeding caterpillars, found on apple trees during May and early June, which occasionally produce the same

kind of injury. Many of these are of rare or intermittent occurrence while others are present in small numbers nearly every year. Prominent among these are the palmer worm (*Ypsolophus ligulellus* Hüb.) and the oblique-banded leaf-roller (*Archips rosaceana* Harris). The latter has two broods each year, the first of which is present at the same time as the single-brooded fruit-tree leaf-roller. The bud moth is known occasionally to eat holes in the young fruit in a manner similar to that of the leaf-roller and green fruit-worm.

LATE APPLE WORMS

During the middle and latter part of the summer, a number of species of caterpillars appear on the trees and several of these occasionally feed on the fruit.

Injury.— In July and August the second brood of the oblique-banded leaf-roller may be found which closely resembles the single-brooded fruit-tree leaf-roller. The caterpillar fastens a leaf to the fruit and feeds beneath it. The injury appears as an irregular area of shallow excavation. (See Fig. 26, *a*.)

A

FIG. 26.— LATE APPLE WORMS: *a*, OBLIQUE-BANDED LEAF-ROLLER; *b*, WHITE-MARKED TUSSOCK-MOTH.

Larvæ of the white-marked tussock-moth (*Hemerocampa leucostigma* Smith and Abbot) are also known to feed on apples occasionally during June and July, and in some years become numerous enough to cause serious losses to the crop.

Wounds made in apples when they are half grown or larger do not form a scar of pale brown new skin as in the case of the green fruit-worm and other insects feeding in May and early June, but instead a dark, thick, corky callus forms over the exposed flesh of the fruit. If sufficient growth takes place later, the callus will crack and reveal a paler brown surface between the dark brown scales. (See Fig. 26, *b*.) In the case of tussock-moth injury, the scales are widely separated, since most of the feeding is done at an intermediate time.

Young tussock-moths may exist on the same trees with nearly mature fruit-worms, so that at any time during the season external feeding may occur and no dividing line can be drawn between early and late injury. However, the tussock-moth does not often feed on fruit except at the time of an outbreak when the grower will usually be aware of the cause.

The work of the second brood of the oblique-banded leaf-roller is probably the most common injury of this type occurring late in the summer. The injury can be distinguished by the thick corky callus or if the wounds are made in practically mature fruit a callus does not form but the flesh turns a brownish color and dries out or rots. Scars resulting from late feeding cavities can be distinguished from other forms of injury by the same characters as described under early apple worms.

Control.— A spray applied ten days or two weeks after the calyx spray should be most effective in the control of the tussock-moth. For second brood leaf-roller a spray applied about 30 days after the calyx spray and the one for second brood codling moth, about August 1, are most effective. Lead arsenate is the active ingredient for both insects. In case of serious outbreaks of any caterpillar, where they have gained considerable growth before special control measures are taken, an extra thoro spray of nicotine sulphate (1–800) and soap (4 lbs. to 100 gals.) may give some relief.

FIG. 27.— BUD MOTH.

BUD MOTH

(*Tmetocera ocellana* Schiffermüller)

The larvæ of the bud moth web together the young leaves and blossoms of the growing buds and live within the cluster. Later they sometimes attack the young apples. There is but one brood annually. The small, dark brown caterpillars hatch from the eggs in mid-summer, hibernate thru the winter, and become full grown in June of the following year.

Injury.— Probably the greatest injury by bud moth is due to the weakened condition of affected blossom clusters, thus preventing in large measure the setting of fruit. Feeding cavities in the young apples which remain, result in a scar similar to that caused by green fruit-worms. The larvæ of the new generation appearing in late summer feed mostly on the foliage but occasionally may tie a leaf to an apple and feed on both. The injury appears as small irregular areas of surface feeding and numerous shallow holes, all limited to the space covered by the leaf. (See Fig. 27.)

Control.— Three of the regular sprays contribute to the control of the bud moth. These are the delayed dormant, especially if applied somewhat later than is advisable for aphid control; the blossom-pink; and, of less importance, the calyx spray. A spray gun or any driving spray, under high pressure, gives the best results. Open, well pruned orchards are least susceptible to bud moth attack.

APPLE RED BUGS

(*Lygidea mendax* Reuter, *Heterocordylus malinus* Reuter)

There are two species of small, swift-running, red, plant bugs which have very similar life histories and injure the fruit in the same manner. The bright red species hatches about blossoming time, while the darker one appears a little earlier. Both species reach maturity and disappear late in June or early in July. There is but one generation each year. The presence of red bugs in an orchard may be detected early by the appearance of reddish-brown spots on the young terminal leaves. (See Plate I, fig. 5.)

FIG. 28.— APPLE RED BUG.

Injury.— Apples injured by red bugs bear shallow dimples or funnel-shaped pits and if these are numerous the fruit is considerably deformed. (See Fig. 28 and Plate II, fig. 5.) The damage is done by the insect piercing the flesh of the young apple with its beak while feeding. This has a greater destructive effect than a mere

pin prick. By the manipulation of the beak or by the toxic action of some secretion from the insect a small portion of the growing pulp just beneath the skin is destroyed. Growth is retarded at this point and eventually a funnel-shaped pit is formed. When very young fruits are attacked greater distortion follows. In our experiments this was the only conspicuous effect; but Knight[1] describes instances in which the growth of the apple caused a rupture of the skin, resulting in irregular scars or russeted areas. This form of injury has been noted in a number of orchards where red bugs were exceptionally abundant and is well illustrated in Plate IV, fig. 1.

The work bears considerable resemblance to that of the plum and apple curculios. A knotty pitted apple resulting from the early feeding of plum curculio can usually be distinguished by the presence of round or semicircular scars accompanying the pits. In the case of red bugs the pits on a ripe apple are usually entirely smooth or with an irregular area of roughened or "russeted" skin. The pits caused by apple curculio can be identified by cutting into the apple to disclose the corky path of the insect's long beak thru the flesh of the fruit.

Apples severely injured by red bugs have hardened areas in the flesh beneath the pits, which make them undesirable for cooking purposes; but, according to a correspondent, they can be utilized by running the cooked material thru a colander, to obtain a smooth apple sauce.

Control.— The red bugs are difficult insects to control by growers who do not practise high standards of spraying, but experience has demonstrated very clearly that these pests can be efficiently combated by adding nicotine sulphate to the blossom-pink and calyx sprays. For the last few years the latter spray has been most effective, due to the greater prevalence of the later hatching species. For extreme infestations it may be advisable to give an extra drenching spray of nicotine sulphate, 1 pint to 100 gallons of water, to which has been added 4 or 5 pounds of soap. A bright warm day is the best time for the application, and on account of the activity of the insect it is better to spray each tree all the way around before going to the next. Care should be taken to reach the under sides of the leaves on all terminal growth.

[1] Cornell Univ. Agr. Exp. Sta. Bul. 396. 1918.

PLUM CURCULIO

(*Conotrachelus nenuphar* Herbst)

Altho more destructive to the stone fruits, the plum curculio causes considerable damage to apples by disfiguring the surface with the feeding and oviposition punctures of the adults. The beetles appear in the spring and continue their work from the time the fruit sets until the end of the summer.

Injury.— As a result of the extended period of activity several kinds of injuries may appear on the ripe fruit. The earliest injuries appear as brownish scars, usually semicircular in shape, and often have a trace of a groove or depression on the straight side. (See Fig. 29, *a*.) These result from the crescent shaped oviposition punctures which have become expanded due to the growth of the fruit. Early feeding punctures heal over and leave only light brown circular scars on the skin. (See Fig. 29, *b* and Plate II, fig. 4). These may be situated in a depression or, occasionally, may protrude slightly above the general surface.

Fig. 29.— Plum Curculio: *a*, Early Egg Punctures; *b*, Early Feeding Punctures; *c*, Late Feeding Punctures.

Late feeding punctures remain as permanent cavities in the surface. (See Fig. 29, *c*.) The opening at the surface may be at first about one-sixteenth of an inch wide, but the cavity beneath has been enlarged by feeding beneath the skin as far as the beetle could reach with its beak. A section cut thru a feeding puncture reveals a more or less spherical cavity one-eighth of an inch or more in diameter. A ring of dark brown discoloration forms about the opening which becomes enlarged due to the drying of the skin. Occasionally, when many feeding holes are close together, a small area may be so undermined as to collapse and a large rotten spot develop. Mature, picked apples never contain the grubs or larvæ of the curculio because the development of the larva either causes the fruit to fall early or the growth of the apple kills the grub.

The illustration (Fig. 29) shows the several types of injury on a normally shaped apple, but if there is an excess of the early feeding and oviposition the apple will be pitted and knotty. Such fruit may resemble the work of the apple red bug; but brown, round, or semicircular scars will distinguish it. Curculio scars are different from those of the fruit worms in their smaller size and less corky surface. Late feeding punctures can be distinguished from codling moth holes by their shallow depth and the absence of excrement.

Control.— The first two sprayings for codling moth also help to control the plum curculio, but if the latter is very numerous additional applications may be advisable. Headlee[1] states that " satisfactory control of the plum curculio on apple has been obtained thru maintaining a coating of summer-strength commercial lime-sulfur (1 gallon to 40 gallons of water) and arsenate of lead (2 pounds to 50 gallons) on fruit and foliage from the fall of blossoms until a period of three weeks has passed. To maintain this coating, the ordinary spraying schedule must be modified by substituting for the spray recommended ten days after the blossoms drop a treatment one week or less after the blossoms fall and another treatment ten days later." The best horticultural practices are found to be most unfavorable for the development of the curculios. Clean farming reduces the hibernating quarters of the beetles, and frequent shallow cultivation between July 10 and August 10 destroys many of the pupæ in the ground. Open, cultivated orchards are least infested with curculios because direct sunlight kills the larvæ in the fallen apples.

APPLE CURCULIO

(*Anthonomus quadrigibbus* Say)

The apple curculio breeds abundantly in wild crab and thorn apples, but is of much less importance in apple orchards than its relative, the plum curculio. The beetle resembles the plum curculio but has a slender bill nearly as long as the body. The adults appear and begin feeding and egg-laying in the young fruit just after the blossoms drop, and continue work until about the middle of July. The second brood of beetles do little feeding but go into hibernation soon after emerging.

[1] N. J. Agr. Exp. Sta. Rpt. 1918, 16-17. 1919.

Injury.— Externally the injury by the apple curculio appears usually as a deep depression with a small scar at the bottom. A section cut thru the center of the pit shows a thin hardened core leading toward the heart of the apple and terminating in a small cavity made by the long beak of the insect. (See Fig. 30, *b*.) Occasionally the area around the puncture becomes elevated so that the pit appears as a crater-like hole at the summit. (See Fig. 30, *c*.) Late oviposition cavities do not cause a deep pit to develop and are about one-eighth of an inch deep and half as wide, with a small opening at the surface. (See Fig. 30, *a*.) The development of a young grub within the fruit does not always cause it to fall but it becomes stunted and shriveled and after the insect leaves it dries up.

FIG. 30.— APPLE CURCULIO: *a*, LATE EGG PUNCTURES; *b*, FEEDING PUNCTURE; *c*, AREA AROUND FEEDING PUNCTURE.

Control.—The insects thrive only in crowded, uncultivated orchards, so that proper pruning and clean cultivation are the best preventive regulations. In case of an infestation by this insect the wild crab and thorn apples in the vicinity should be destroyed. The orchard should be cultivated and the infested apples which drop should be fed to stock or raked every few days into the sunlight, which is fatal to both larvæ and pupæ.

ROSY APPLE APHIS

(*Aphis sorbi* Kalt.)

Two common species of apple aphids, the rosy apple aphis and the green apple aphis, may be responsible for the abnormal development of fruit described below. The destructive work of the rosy apple aphis is confined to a period of about two months in the spring, but it has greater power for malformation, and is more often the causal agent than the green apple aphis which remains on the trees thruout the year. The rosy aphis hatches when the young leaves

are beginning to appear at the tips of the buds, usually the latter part of April, and the last of the winged females leave the trees the latter part of June. (See Plate I, fig. 9.)

Injury.— A bad infestation of rosy aphis on a fruit spur, in some way not well understood, often causes all of the apples to set and the result is a cluster of small under-developed fruit. The characteristic cluster apple is compressed from pole to pole, the calyx end is slightly expanded and presents a broad, flattened area, while the portion immediately surrounding the calyx is much wrinkled and puckered. (See Fig. 31.) Frequently the growth of one side of the apple is greatly inhibited so that a lopsided fruit results.

FIG. 31.— ROSY APPLE APHIS.

Recent work by this Station[1] has shown that besides a reduction in the size of the fruit, there is a decrease in the weight of the seeds. The amount of variation in the above characters is greater for aphis apples than for normal fruit. Apples under 30 mm. in diameter are often sterile or have only a few seeds.

Control.— By delaying the dormant spray until the buds show green at the tip, the newly-hatched aphids which congregate on them can be killed by adding nicotine sulphate to lime-sulphur solution at winter strength. The spray should be applied before the leaves have separated enough to allow the aphids to conceal themselves and care should be taken to spray all the buds thoroly.

SAN JOSE SCALE

(*Aspidiotus perniciosus* Comstock)

This well-known insect normally lives on the bark, but when abundant many of the larvæ wander to the fruit and leaves, where they settle down and form their scale covering. The larvæ appear

[1] Parrott, P. J., Hodgkiss, H. E., and Hartzell, F. Z. N. Y. Agr. Exp. Sta. Tech. Bul. 66. 1919.

between the middle of June and the middle of July, depending on the season, and are in evidence thruout the summer.

Injury.— On the fruit the scales have a tendency to cluster about the calyx and stem. A reddish discoloration of the skin forms about each insect as a circular spot, considerably wider than the scale itself. (See Fig. 32 and Plate I, figs. 1 and 2.) When the fruit is badly infested the scales overlap and form a grayish scurvy deposit on the surface.

FIG. 32.— SAN JOSE SCALE.

Orchards situated near an apiary may bear a few apples having a slight blemish due to a drop of excrement from flying bees. A red area forms around the small pellet giving it the appearance of a scale on the fruit. Other orchard scales rarely occur on the fruit.

Control.— The standard remedy for San Jose scale is lime-sulphur solution, used while the trees are dormant or just as the buds show green at the tip. (See the table on page 394 for directions for the dilution of lime-sulphur.)

FIG. 33.— ROSE CHAFER.

ROSE CHAFER

(*Macrodactylus subspinosus* Fab.)

In sandy regions rose chafers often become suddenly abundant and cause great injury to crops within a very short time. There is but one brood of the beetles annually, and in New York State they emerge about the middle of June. On account of the large size of the apples at this time the amount of deformation is only slight compared to the extent of the injury.

Injury.— The large irregular holes which the beetles excavate in the sides of the fruits do not heal over like wounds made early

in the season, but form a thick corky callus, the surface of which often becomes cracked in the bottom of the cavity. (See Fig. 33.) If the injuries are too extensive, as often happens when the beetles are numerous, rot starts around the holes and the apple drops.

Control.— Many methods have been used in an attempt to control this pest but most of them have been unsuccessful. Ordinary poison sprays fail to protect the plants, but sweetened arsenical sprays have sometimes given partial control. The formula for the latter is 8 pounds of lead arsenate and 2 gallons of cheap molasses to 100 gallons of water.

CASEBEARERS

(*Coleophora fletcherella* Fernald, *C. malivorella* Riley)

FIG. 34.— CASEBEARERS: *a*, EARLY FEEDING SCAR; *b*, LATE FEEDING SCAR.

There are two species of casebearers on apple, the cigar casebearer and the pistol casebearer. Both insects have but one brood a year. The casebearers usually feed on the leaves by making small mines in them, but they occasionally feed on the fruit both when young and later in the year. The work is similar to that on the leaves and consists of a small round hole with a shallow cavity extending in all directions for a short distance. (See Plate I, fig. 4.)

Injury.— The work on the young fruit develops into small round corky scars with a depressed center. (See Fig. 34, *a*.) The small and shallow feeding punctures of this insect do not give rise to distortions such as accompany curculio scars, and are much less common. Late casebearer feeding punctures in fruit appear as a tiny hole opening into a small cavity, and surrounded by a ring of black, dried skin. (See Fig. 34, *b*.) Sometimes a whitish exudate appears. These are similar to the late curculio punctures except for their smaller size, and closely resemble certain "stings" by late codling moth worms in cases where the young worm dies or leaves the hole after entering.

Control.—The arsenical sprays used in the regular spraying schedule keep these insects under control, the first two being most effective. The insect seldom causes serious injury in well-regulated orchards in this State.

APPLE-SEED CHALCID

(*Syntomaspis druparum* Boh.)

The apple-seed chalcid is of little economic importance, since it affects the seeds more than the flesh of the apple and usually attacks only small-fruited varieties and crab apples. The adults appear in June and deposit eggs in the seeds of the apples.

Injury.—The only injury visible on the mature fruit is a small black dot often in the center of a shallow depression. A section cut thru the black dot will reveal the effect of the ovipositor of the adult insect as a thin brownish line of hardened tissue extending to the core. (See Fig. 35.) The seeds which contain maggots are flexible and generally of a pale color.

FIG. 35.—APPLE-SEED CHALCID.

Control.—Because of the slight degree of injury caused, control measures are not necessary. If preventive measures are desired, a complete destruction of all apples left under the trees in the fall would be effective, since the insects hibernate in the seeds.

DEFECTS OF APPLES THAT MAY BE CONFUSED WITH INSECT INJURIES

There are a number of natural and artificial causes producing a scabbing or russeting of fruit which to the uninitiated might be confused with certain scars of insect origin previously described. Scabbing or the formation of corky tissues results from an irritation of the skin of the fruit during the growing season. This may be purely mechanical, or due to the action of frost, fungus growth, or spray chemicals which kill the epidermal cells or dissolve the waxy coating.

MECHANICAL INJURIES

When an immature apple receives a bruise from a single blow such as caused by a falling hail stone, the starch in the bruised area is not converted into sugar during the ripening process, so that the injured part remains hard. Typical hail pecks appear as rounded sunken areas often of a greenish color like an unripe fruit with brownish tissue beneath the skin. Usually the skin remains smooth and unscarred. (See Fig. 36, *a*.)

FIG. 36.—MALFORMATIONS OF APPLE WHICH MAY BE CONFUSED WITH INSECT INJURIES: *a*, HAIL INJURIES; *b*, INJURY BY RUBBING; *c*, FROST INJURY; *d*, SPRAY INJURY; *e*, SUNBURN; *f*, SCAB; *g*, BITTER PIT.

Constant rubbing of a fruit against a limb produces a rough scar on the side affected. The surface generally bears large, quadrate, corky scales, and the injury is most pronounced in the center of the area where the irritation most commonly occurred and is more or less blended into the clear skin at the edges. (See Fig. 36, *b*.)

FROST INJURY

The injury ascribed to late frost is quite typical and should be easy to recognize, especially when many fruits from the same tree or orchard bear marks having essentially the same characteristics. The common type of frost injury is a russeted band extending com-

pletely around the apple midway between stem and calyx. Sometimes it is located nearer the lower pole and forms a ring around the calyx. The margin is usually irregular or lobed and sometimes the ring is broken into a series of patches. It differs from injuries due to spray and rubbing in having a definite clear margin and in this respect resembles the work of fruit-worms, but the essential ring-like character of the majority of specimens should distinguish it from all insect work. (See Fig. 36, *c*.)

SPRAY INJURY

Russeted or corky areas due to the action of certain sprays are marked by great irregularity and lack of definite limits. Often the main part of the scar blends into the clear skin thru a series of corky patches of gradually diminishing size. A severely injured specimen is distorted in shape due to inhibition of growth in the affected portion and the scar may bear wart-like malformations or gaping cracks. The lack of a definite margin of the injured area distinguishes typical spray injury from insect work. (See Fig. 36, *d*.)

SUNBURN

Late applications of spray applied during a period of hot bright days, often produce a brown area on the exposed side of the fruit, which has the appearance of being burned or baked. This may occur on trees that have not been sprayed and is due to excessive heat and sunlight, or to the lens action of drops of water following a shower. Sunburn commonly appears as a single, circular area of smooth, dark brown skin having a baked appearance. The burned portion is usually slightly depressed and often developes a gaping crack extending around the margin. There are no insect injuries which could be confused with typical sunburn. (See Fig. 36, *e*.)

SCAB

Early infection by apple scab fungus results in a corky area and accompanying distortion of the fruit, which bears a strong resemblance to the work of fruit-feeding caterpillars. The injured portion is generally somewhat circular in outline, unless several spots have merged into one, and the margin is slightly scalloped or lobed, but

there is little tendency to blend into the clear skin. The chief character to distinguish scab scars from fruit-worm injury is one of color. In the former case the area is broken up into small patches of thickened corky tissue which has a greenish black or sooty color, the spaces between are brown while the margin may be more or less silvery. (See Fig. 36, *f* and Plate II, fig. 6, *a*.) Caterpillar scars may have dark brown corky scales but they lack the sooty color. In case of severe scab infection large open cracks develop which will distinguish it at a glance from any insect injury.

BITTER PIT

Bitter pit, Baldwin spot, dry rot, brown spot, and fruit pit are names given to a disease of obscure origin, which appears on the surface as small sunken discolored areas associated with corky brown masses of collapsed cells within the flesh. The sunken spots have a smooth, unbroken skin and are green or brown in color. The shape and size varies, but usually they are roughly circular and about one-eighth of an inch in diameter. In some cases all of the corky areas of the flesh are so deeply situated that no surface marks occur. (See Fig. 36, *g*.)

Many apples affected with bitter pit bear a close resemblance to those infested with apple maggots before the latter have reached a mature size so as to leave unmistakable holes in the flesh. The distinguishing characteristics of each are pointed out in the discussion on the maggot (page 366). Red bug and aphis injuries have been confused with bitter pit but the work of these two insects is so characteristic that there need be no mistake as to their identity.

SPRAY DEPOSITS

Late sprays, especially on early varieties, sometimes leave an unsightly arsenical deposit on the surface at picking time. A case is on record where a city board of health condemned quantities of such fruit on the theory that it had sufficient poison to be dangerous. While arsenic in toxic quantities has been reported in several instances, the danger from eating sprayed fruits has generally been greatly exaggerated. Chemical analyses have shown that it would require the spray from several hundred apples as they are usually treated in this State to make a minimum dose of poison dangerous

to human beings. However, to overcome prejudice in this respect and to prevent controversy, as well as to give the fruit a better appearance, it is sometimes advisable to wipe it and for this purpose cheap cotton gloves are better than a rag.

ACTIVITIES OF INSECTS ON FRUITS AFTER HARVEST

A glance at Chart VI will show which insects are active at the time of picking and consequently may be looked for in piled or stored fruit. If any injuries found in graded apples can be identified as the work of early summer insects, the responsibility for their presence can be placed absolutely on the person packing the fruit. This is most likely to be true for all other injuries but there is always a possibility that some of the late summer insects may escape observation and be put in storage.

The oblique-banded leaf-roller, the bud moth, and casebearers have been observed feeding on apples piled in the orchard. It seems probable that the plum curculio might do likewise but no notes have been taken to that effect. The more important insects likely to be found in storage are discussed separately.

CODLING MOTH

Many instances have been recorded in which codling moth larvæ have emerged from apples in the store room or in barrels and have spun their cocoons in some protected crevice or corner near by. The codling moth worm has never been known to feed on more than one apple except in a few cases where two apples are in contact while still on the tree. It is practically certain, therefore, that no injury by this insect occurs in apples kept in storage if they were sound at picking time, altho the worms may continue to feed on infested fruits in storage if the temperature is high enough. Reports of horticultural inspectors bear out these statements and also show that larvæ or pupæ of the codling moth are rarely found in storage except among ungraded or "tree run" apples.[1]

LESSER APPLE WORM

If the lesser apple worm were to become more abundant it would probably attract more attention in stored fruit. The small mines

[1] Parrott, P. J. Proc. West. N. Y. Hort Soc. 1917, 72-81.

EXPLANATION OF PLATE I

FIG. 1.— San Jose scale on a twig. (Enlarged)

FIG. 2.— Portion of Fig. 1 greatly enlarged.

FIG. 3.— Bud moth larva and work on young leaves.

FIG. 4.— *a*, Case of young cigar casebearer; *b*, Cigar casebearer, full-grown larva mining into apple leaf; *c*, Pistol casebearer.

FIG. 5.— Red bugs on young leaves punctured by them: *a*, Adult; *b*, Young nymph.

FIG. 6.— Work of leaf blister-mite.

FIG. 7.— Green fruit worm on young apple.

FIG. 8.— Leaf-roller and work on fruit and leaves.

FIG. 9.— Rosy apple aphis: *a*, Winged migrant, female; *b*, Wingless female.

9

PLATE I.—SOME APPLE INSECTS CONTROLLED BY SPRAYING

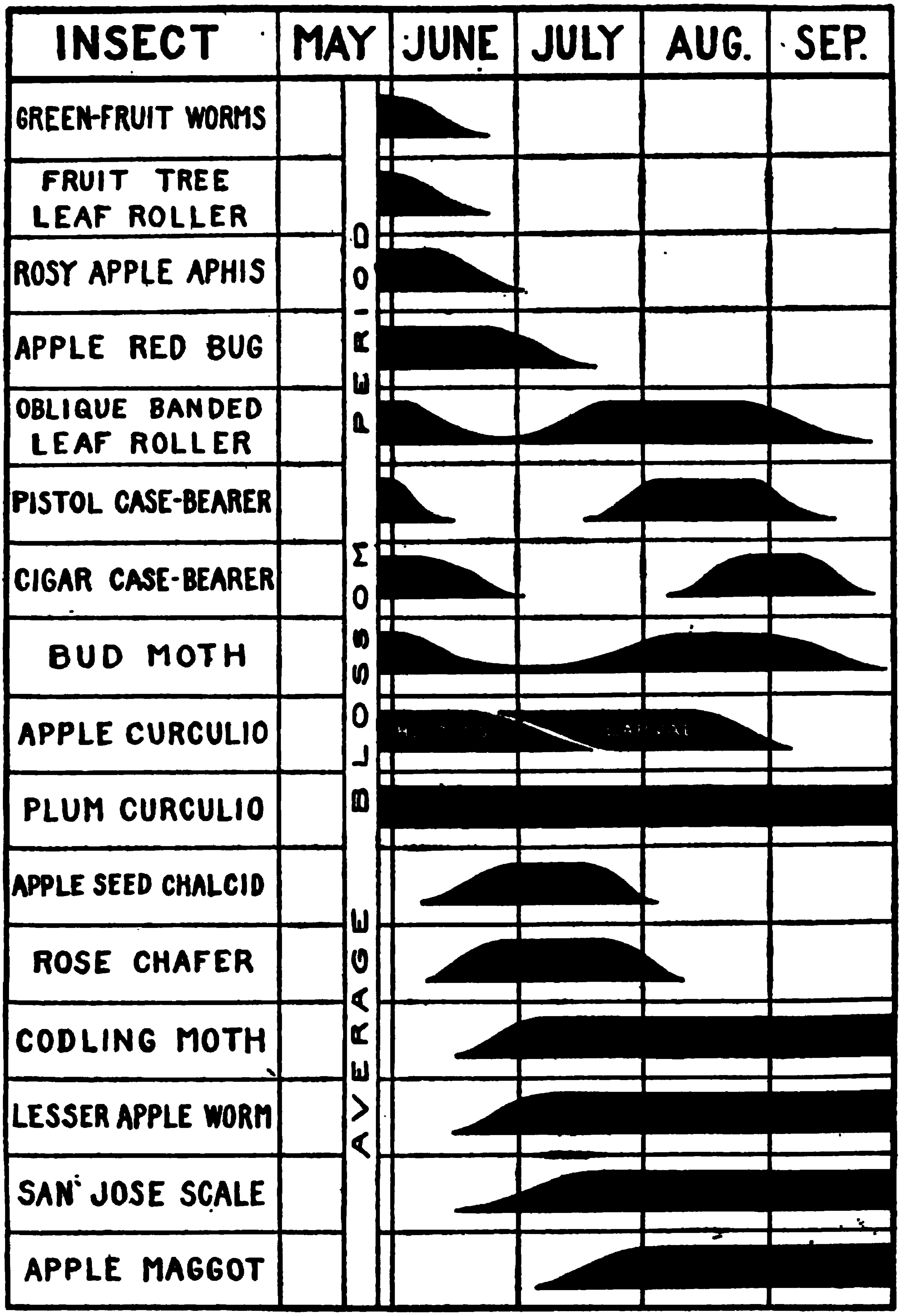


Chart VI.— Periods During Which the Insects are Actively Injurious to the Fruit but not Necessarily the Proper Time for Combating Them.

Explanation of Plate II

Fig. 1.— Codling moth: *a*, Side injuries due to entrance of second brood larvæ or late first brood; *b*, Entrance hole of early first brood; *c*, Exit hole.

Fig. 2.— *a*, Late brood of leaf-roller; *b*, Lesser apple-worm.

Fig. 3.— Apple maggot.

Fig. 4.— Plum curculio: *a*, Late feeding punctures; *b*, Scars from early feeding and egg-laying punctures.

Fig. 5.— Red bug.

Fig. 6.— *a*, Apple scab; *b*, Type of scar caused by green fruit worm and leaf-roller.

b

b

a

1 c

2

x

b

3

4

b

5

6

Plate II.—Injuries Common to Apples.

Period for spraying	Materials in spray mixtures*	Insects and diseases affected
Delayed dormant	Lime-sulphur (1–8, winter strength)	Scale Blister-mite
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Bud moth Leaf-rollers Casebearers
When buds show green at tips	Nicotine sulphate, ¾ pint	Aphids
Blossom-pink	Lime-sulphur (1–40, summer strength)	Scab
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Green fruit-worms Bud moth Leaf-rollers Casebearers
When blossoms show pink	Nicotine sulphate, 1 pint	Dark apple red bug
Calyx	Lime-sulphur (1–40 summer strength)	Scab
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Codling moth Green fruit-worms Bud moth Curculios Lesser apple worm
When last of petals are falling	Nicotine sulphate, 1 pint	Dark and bright apple red bugs
Later sprays to be determined by weather conditions. Two sprayings often made are (1) two to four weeks after calyx spray, and (2) about the 1st of August, when the second brood of codling moth appears.	Lime-sulphur (1–40, summer strength)	Scab
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Codling moth Curculios Lesser apple worm Apple maggot

* Reduce figures for lead arsenate to one-half if powdered form is used.

PLATE III.— SPRAYING SCHEDULE FOR APPLES.

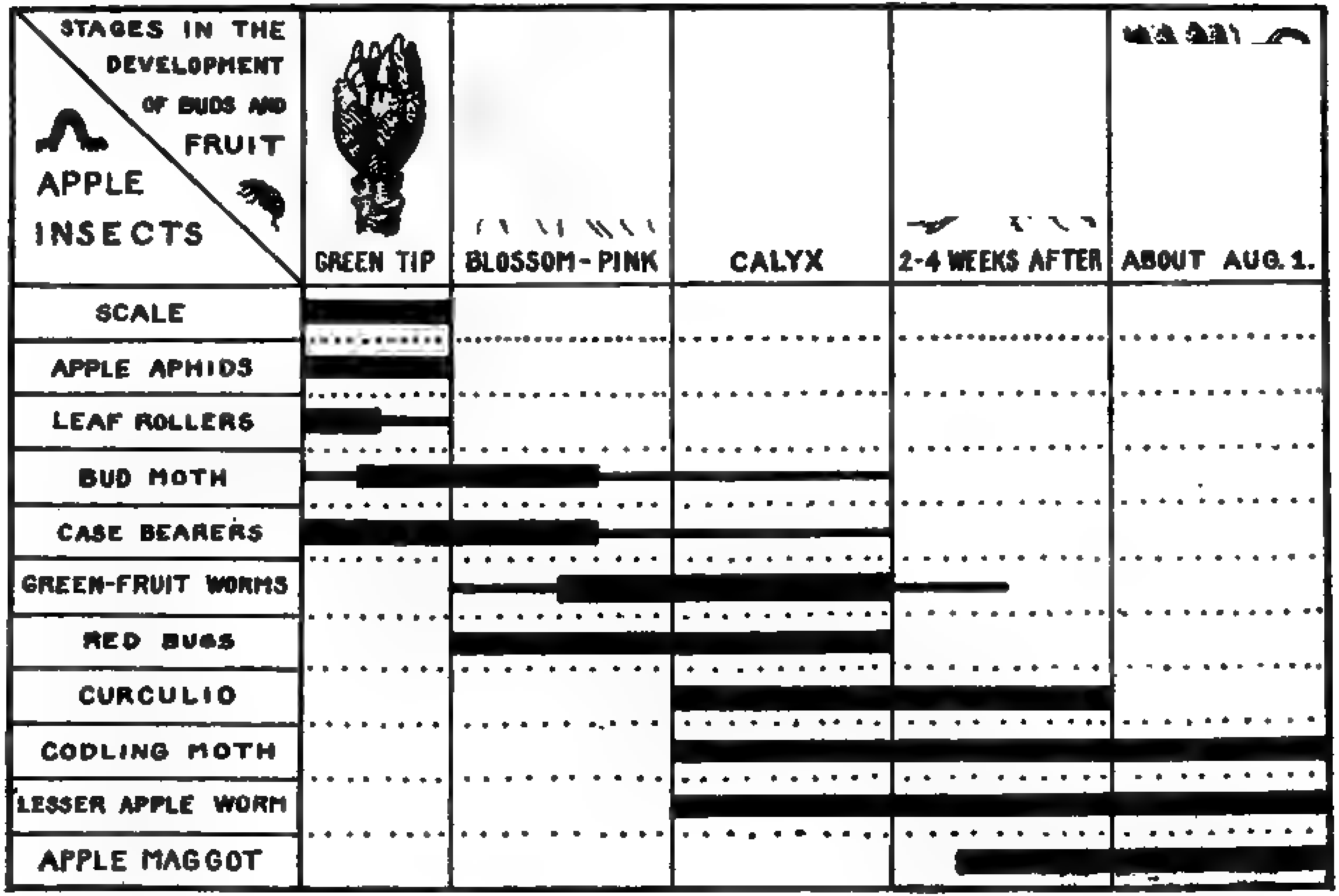


Chart VII.—Stages in Development of Buds and Fruit when Sprays should be Applied. The Heavy Bars Indicate the Most Effective Times for Control. The Narrow Bars Show other Periods when Control Measures Can be Used.

of this insect when partly concealed in the hollow around the calyx or stem easily escape detection. This worm differs from the codling moth in that it does not reach maturity so early in the fall, and in the fact that it will pass from one apple to another while feeding in storage. Quaintance[1] states that in several instances important injury has been done by larvæ in barreled fruit.

SAN JOSE SCALE

The chief injury from San Jose scale occurs during the growing season, and breeding by the insect after picking is possible only at temperatures too warm for proper storage conditions. Experiments conducted at this Station demonstrated that the larvæ were unable to develop at an average temperature of 35° F. but were able to develop to the black stage at a temperature of 45° F. At the latter temperature further growth was checked.[2] Quaintance[3] has shown that only scales about one-third grown can continue to live on fruit held at a cold storage temperature of from 30° to 32° F. for the ordinary storage period. Those which survive would require several weeks to reach a reproductive age, and fruit removed from storage is not ordinarily held that long.

APPLE MAGGOT

Since the apple maggots remain small until the flesh of the apple begins to ripen, it sometimes happens that infested winter apples show no external evidence of injury at picking time except the tiny egg punctures. These would easily escape notice and the fruit might go into storage where the maggots will continue to feed and grow. If the weather continues warm for a period after picking time such fruit will deteriorate rapidly.[4] Low temperature prevents the growth of the maggots, and continued exposure near the freezing point may even kill them, but it cannot repair the destructive work already done and infested apples do not keep so well as healthy fruit. However, cold storage can be of practical value if slightly injured fruit is placed in it immediately after picking and held until such time as it can be utilized.

---

[1] U. S. Dept. Agr. Bur. Ent. Bul. 68, Pt. V. 1908.
[2] Lowe, V. H. and Parrott, P. J. N. Y. Agr. Exp. Sta. Bul. 193, 363–67. 1900.
[3] U. S. Dept. Agr. Bur. Ent. Bul. 84. 1909.
[4] O'Kane, W. C. N. H. Agr. Exp. Sta. Bul. 171. 1914.

A B

Plate IV.—Comparison of Red Bug (*A*) and Plum Curculio (*B*) Scars on Mature Apples.

EFFECT OF INSECT INJURIES ON KEEPING QUALITIES OF APPLES

It is well known that apples with an imperfect or broken skin do not keep so well as those with a smooth clear skin. The fruit may be perfectly sound at picking time, but if it is scarred or russeted by spray or mechanical injury, or by early feeding of insects it will shrivel sooner than a normal apple. Any break in the skin, such as caused by an insect feeding on the mature fruit, permits rapid evaporation of the cell sap and makes a starting point for an invasion of soft rot. Insect larvæ working within the flesh of the apple generally cause premature ripening, and also produce ideal conditions for the growth of rot organisms. The apple maggot is especially serious in storage since it often undergoes most of its development after the fruit is picked and will reduce the whole apple to a rotten pulp. Even in cold storage, which stops the growth of the maggot, the infested apples do not keep so well as normal fruit.

To summarize, any extensive insect injury on an apple, whether a scar or an open wound, reduces its keeping qualities and it should not be included with fruit that is to be stored for a long period of time. Scarred or russeted fruit should not be included in lots to be held in storage later than February 1.[1]

EFFECT OF INSECT INJURIES ON YIELD

Insect injuries to the fruit not only reduce the value of the picked fruit, but many of the insects discussed materially reduce the yield by destroying blossoms, preventing the setting of fruit, and causing the apples to drop prematurely. It is difficult to estimate this loss since a large amount of the young fruit drops normally, and when a crop is heavy a certain amount of thinning is desirable. In years when the yield is normally small this destruction of young fruit would become of greater importance. Often the insects will attack the finest young sets in a cluster so that perhaps none will be retained on that particular spur.

The insects which may cause important reductions in yield are fruit-worms, bud moth, leaf-rollers, plum curculio, apple maggot, apple curculio, and aphids. The first three cause losses by eating

[1] Greene, L. Iowa Agr. Exp. Sta. Bul. 144. 1913.

Beaumé and are diluted 1 to 8 for winter spray and 1 to 40 for summer treatments of apples.

TESTING AND DILUTING CONCENTRATED LIME-SULPHUR

The proportions of lime-sulphur and water used to make up the dormant and summer spraying mixtures depend on the strength of the concentrated solution. This can be tested with a Beaumé hydrometer, which is an instrument used for determining the weight and density of liquids. For use with lime-sulphur the hydrometer should be designed for heavy liquids testing as high as 35 degrees. The solutions should be tested when cold, and it is important to keep the hydrometer perfectly clean. After determining the density of the solution it should be diluted for spraying according to the table which follows.

DILUTION TABLE FOR LIME-SULPHUR WASH

DENSITY OF SOLUTION IN DEGREES BEAUMÉ	DILUTIONS FOR DELAYED DORMANT SPRAY, PROPORTIONS OF LIME-SULPHUR AND WATER TO MAKE 100 GALLONS		DILUTIONS FOR SUMMER SPRAYS, PROPORTIONS OF LIME-SULPHUR AND WATER TO MAKE 100 GALLONS	
	Lime-sulphur	Water	Lime-sulphur	Water
	Gals.	*Gals.*	*Gals.*	*Gals.*
36	10	90	2.2	97.8
35	10¼	89¾	2.3	97.7
34	10¾	89¼	2.4	97.6
33	11¼	88¾	2.5	97.5
32	11¾	88¼	2.6	97.4
31	12¼	87¾	2.7	97.3
30	13	87	2.8	97.2
29	13½	86½	3.0	97.0
28	14¼	85¾	3.1	96.9
27	15	85	3.3	96.7
26	16	84	3.5	96.5
25	17	83	3.7	96.3
24	18¼	81¾	4.0	96.0
23	19½	80½	4.2	95.8
22	20¼	79¾	4.5	95.5
21	22¼	77¾	4.8	95.2
20	23¾	76¼	5.2	94.8
19	25½	74½	5.6	94.4
18	27	73	6.0	94.0
17	29	71	6.4	93.6
16	31	69	6.8	93.2
15	33¼	66¾	7.3	92.7

Plate V. Influence of Leafhopper on Potato Foliage: *A*, Normal Leaf; *B*, Affected Leaf.

THE LEAFHOPPER AS A POTATO PEST*

P. J. PARROTT AND R. D. OLMSTEAD

SUMMARY

The leafhopper (*Empoasca mali* Le Baron) has derived its reputation as a destructive agent chiefly from its injurious activities on young apple trees. Recently it has been the subject of special study with regard to its economy as a potato pest. The facts secured in this investigation have established an important injurious relationship to potato culture in New York.

Migration of over-wintering leafhoppers to potato plantings began during early June, and the vines were sought for purposes of oviposition as soon as they appeared above the ground. Eggs were deposited largely in the young tender leaves near the growing tips of the plants and oviposition continued until the plants were killed by frosts during early October. With the hatching of the nymphs all stages of the pest were present on the vines during the growing period.

In cage and field experiments feeding by the insects produced small, brownish areas of one-fourth inch or more in width at the tips and occasionally on the margins of the leaflets. The injury became more conspicuous as the season advanced, the brownish or burned areas increasing both in extent and numbers. As tissues became desiccated the margins rolled over the upper surface, leaving a small narrow green area in the central portion of the leaflet.

The disorder attained its greatest intensity during August. At this period nymphs and adults of the second generation of the leafhopper became increasingly abundant and intermingled with them were individuals of the different stages of the first generation. Feeding by both nymphs and adults was attended with injuries to leaf structures.

INTRODUCTION

In Bulletin No. 451 of this Station attention is directed to the injurious activities of various leafhoppers on apple trees. Added significance has recently been attached to one of these species, *Empoasca mali* Le Baron, because of its demonstrated ability to produce material injury to potatoes. Owing to the importance of the potato industry in New York, more knowledge as to its capacities as a pest in this rôle than is now available is desired. It was with this object in view that the experiments herein recorded were planned.

---

* Reprint of Technical Bulletin No. 77, March, 1920.

THE LEAFHOPPER AS A PEST OF POTATOES

In 1876 Osborn[1] recorded the leafhopper (*E. mali*) as a new pest of potatoes, which produced serious wilting of early varieties. From the condition of the plants it was suggested that the species was capable of causing a great amount of damage. A brief account was given of an experiment designed to reduce the numbers of the nymphs and adults on affected plants.

In 1908 the insect was very abundant on potato vines in the leading areas of production in this State, especially in the region of Watertown, and many growers expressed the opinion that it was responsible to a certain extent for the premature dying of the plants.[2] Records of observations of a number of plantings in the vicinity of this town state that both adults and nymphs were very abundant, and could well have been the cause of the shriveling of the plants. As the decline of the plants was chiefly ascribed to a disease officially diagnosed as "tipburn" and as it was not at that time suspected that other factors could produce somewhat similar ill effects, no attempts were made to determine the actual influence of the leafhoppers upon the growth of the plants. In 1909 the insect was reported as abundant on potatoes growing near Saugerties in the Hudson River Valley, and it was noted that infestation of the plants "was accompanied by curling of the leaves, which became brown and brittle." During these two years beans infested with the leafhoppers also showed marked curling and crinkling of the foliage.

The leafhopper was regarded by Webster,[3] as injurious to potatoes, and in 1915 he called attention to the curling of small tender leaves and the stunted growth of plants attacked by the insect.

To Ball,[4] credit is to be given for rescuing the activities of the leafhopper on this host from the domain of conjecture and in directing serious attention to the insect, especially in its relations to "tipburn," which has resulted in a clearer understanding of its status as a potato pest.

SEASONAL NOTES ON ACTIVITIES OF INSECT

On June 10, 1919, the first adult leafhopper was observed feeding on the foliage of a young apple tree in an old neglected orchard. During the following day a few adults were seen flying in a small plat of Irish Cobbler potatoes, and on June 16 more adults were detected in another planting composed of Early Rose potatoes. By the third week in June the migration of the insects from other hosts to potatoes had evidently begun in earnest, as thereafter the creatures were always to be found in these two plats as well as in other plantings.

---

[1] Osborn, H. Iowa Exp. Sta. Bull. 33, 602–605. 1896.
[2] Records by H. E. Hodgkiss of the Department of Entomology.
[3] Webster, R. L. Iowa Exp. Sta. Bull. 155, 394–400. 1915.
[4] Ball, E. D. Wis. Dept of Agr., Bull. 23, 76–102. 1919.

Nymphs were first observed during the second week in June, when they were detected feeding on apple and raspberry foliage. Adults were now very abundant on apple trees, and during the latter portion of June there were evidences of initial injuries to apple foliage. Nymphs of all instars were observed on the foliage, and some leaves of terminal growth displayed characteristic curling.

In an experimental plat of a late variety of potatoes, known as Enormous No. 9, adults were first seen during the first week in July, and a few days later nymphs were observed. Examinations on July 2 of foliage of several early varieties of potatoes for egg deposition indicated that the adult females preferred young shoots for oviposition, as eggs were found only on the new, tender leaves near the tips of the vines, while the lower leaves showed no evidences of egg-laying. At this date nymphs were apparently not abundant, as repeated examinations revealed only a few individuals. Some of these were in the third instar, which would indicate that the nymphs had made their appearance during the last week in June. In the plat of Enormous No. 9, which was the last variety to be planted, it was not until the middle of July that nymphs of the first generation appeared in numbers. In this planting no evidences of injury were observed until the nymphs of the first generation were quite abundant, which was during the latter part of July. At this time there were also large numbers of adults, most of which belonged to the first generation, altho a small percentage of them were of the second generation. The nymphs increased in numbers as the season advanced reaching their maximum abundance during the middle of August. Subsequently there was a slight waning in their numbers, and the diminution appreciably increased after September 1. However, nymphs could always be observed on potato foliage until the first frosts, during the second week in October, destroyed the vines.

The predominance of nymphs during the middle of August was due to an intermingling of forms from both the first and second generations. Coincident with the period, when nymphs were present in maximum numbers, injuries to foliage greatly increased. Actual counts during late August and early September showed that fifty-two per cent of the leaves were damaged to a greater or less degree. Altho the injury continued to develop after this period, it was during the time indicated that the greatest damage occurred.

Counts of the insects on the various experimental plats during the summer showed that mature forms were most numerous at two different periods: During the last week in July when the adults of the first generation reached their maximum numbers; and during the latter part of August and early September when the adults of the second generation were most abundant, altho at this time there were still in existence individuals of the first generation. The interval between August 15 and September 15 was the period of the most severe infestation because of the intermingling of nymphs and adults of the first and second generations.

DESCRIPTION OF INJURY

As first noted in July on the experimental plats, the most obvious injury by the leafhopper was the occurrence of small brownish areas at the tips of the leaflets and occasionally on the margins of the leaflets. Usually the terminal leaflet and those adjacent to it were first affected. With some plants this form of injury was preceded or accompanied by the curling of the foliage of the terminal growth in which the tips of the affected leaves were bent under and the margins were upturned. Superficially this resembled the disease known as leaf-roll.[1]

As the season advanced the destruction of the tissues became more evident as the injured areas increased considerably both in numbers and extent. The discoloration progressed from the tip towards the base of the leaflet and from the margins towards the midrib. As affected structures dried the margins rolled over the upper surface, leaving only a small narrow strip of green tissue in the center of the leaflet (Plate V). Prior to the desiccation or browning of the tips and margins there was an intermediate stage when the affected areas displayed a greenish yellow tinge. This appeared first about the margins and preceded the burning or drying up of the tissues inwardly towards the midrib. The condition was more prevalent during the latter part of the season, for then there was considerable yellowing of the foliage.

Of leaves subjected to attacks by leafhoppers, every leaflet oftentimes showed injury to a more or less degree. The terminal leaflets usually exhibited the greatest amount of burning, while those nearer the base of the leaf usually displayed comparatively larger areas of green tissue. As the injury progressed the leaflets curled and completely dried up and eventually the petiole itself became withered so that slight disturbance of the plant produced defoliation of the affected stems. If infestation was severe the foliage over an entire planting usually presented a brownish appearance, which was especially conspicuous by the middle of August. In exceptional instances all the leaves were affected, but usually the injury was most noticeable on the areas of the plant immediately below the new growth. The apparent reason for this is that the adults seem to prefer the tender, growing leaves for purposes of oviposition, while the nymphs, when they hatch, show less tendency to migrate and feed largely upon or near the leaflet where they were hatched. Owing to this habit of restricting their feeding activities to a single or few leaflets, the nymphs produce most of the damage.

The adults are capable of causing injury but, unlike the nymphs, those engaged in egg-laying are active and resort to flight at the

---

[1] In anticipation of the possible criticism that the injuries and abnormalities here attributed to leafhoppers may have been due, in part, to the diseases known as mosaic and leaf-roll, it may be said that, during the entire season, the experimental plats were under close observation by F. C. Stewart, the Station Botanist, who assures us that none of the plants were affected with mosaic and only a few showed even mild symptoms of leaf-roll.

slightest disturbance. Moreover, their preference for new growth in which to place their eggs, coupled with their migratory habits, has the effect of distributing injuries by them and thus preventing the more conspicuous evidences of damages such as arise by the constant feeding of the nymphs in rather small areas of a single or a few leaflets. By reason of the habits of the adults, the terminal leaves, especially when the vines are growing rapidly, seldom show evidences of injury, and the typical discolorations do not appear until the eggs hatch and the nymphs begin to feed.

EXPERIMENTAL STUDIES ON ADULTS AND NYMPHS

CAGE EXPERIMENTS

These experiments were made in a small planting of potatoes of the variety Irish Cobbler. Shortly after the plants appeared above the ground certain of them were covered with breeding cages, which consisted of wooden frames screened with cheesecloth. The frames were five feet in length and of sufficient size to cover from three to four potato vines as grown under commercial conditions. The cages were placed in the plat before the first hibernating adults of *Empoasca mali* had made their appearance on potato plants. In this series there were four cage experiments with checks. One cage experiment without a check is also worthy of mention.

Experiment No. 1.— In this test insects were confined in two cages and one cage was reserved as a check as follows:

Cage 1. Three plants. Confined thirty adults of first generation on July 23.

Cage 2. Three plants. Confined ten adults of first generation on July 25.

Cage 3. Three plants. Check.

All the cages were left undisturbed until October 1 when an examination was made of the different plants. The condition of the vines in the different lots presented most striking contrasts. Every plant in Cages 1 and 2 showed the characteristic browning or burning of the leaves, while the check vines were almost free from injury. An occasional leaflet displayed burned tips, indicating that a few leafhoppers had gained entrance into the check cage. Evidence of the presence of the insects was substantiated by the existence of one or more cast skins on the injured leaflets, which showed that oviposition had occurred and that nymphs had fed on the vines. The injury, however, was barely noticeable as compared with the destructive work of the leafhoppers in the other cages, for with them there was scarcely a leaf on any of the plants that did not display characteristic damages to the leaflets.

Experiment No. 2.— On August 8, three shoots selected from three different plants were covered with gauze bags. The stalks were

margins. At this date there were many adults inside the cage as well as large numbers of nymphs of both the first and second generations on the leaflets. On September 1 the leaves were entirely destroyed, and all that remained of the plant were the bare stalks to which were attached a few dead petioles.

FIELD EXPERIMENTS

These experiments serve a two-fold purpose: First, in showing the destructive capacity of the leafhopper under normal conditions; and second, in indicating the susceptibility of the insect to various spraying mixtures. The details of this effort are presented largely with regard to the former consideration, as it is not intended in this account to discuss methods of control.

The experimental planting, which was about one-half acre in extent, provided for forty-two rows each one hundred eighty feet in length. It was planted to a variety of potato known as Enormous No. 9 on June 6, the sprouts appearing above ground during the following second and third weeks. On the whole the temperatures during the growing period were favorable for growth, and while the weather was quite dry at certain periods the plants did not apparently suffer for lack of moisture. The plats for testing spraying mixtures were arranged as follows:

Plat 1. Two rows. Check.
Plat 2. Six rows. Bordeaux mixture (10–10–100) with six pounds of paste arsenate of lead.
Plat 3. Four rows. China clay, sixty pounds to one hundred gallons of water and ten pounds of soap.
Plat 4. Four rows. Bordeaux mixture (8–8–100) with sixty pounds of lump lime.
Plat 5. Four rows. Bordeaux mixture (10–10–100).

The first spraying was made on July 8, at which time leafhoppers were beginning to appear on the vines. The applications were made with a gasoline power spraying outfit under pressures varying from one hundred to one hundred and fifty pounds. In this work great care was exercised to cover thoroly all surfaces of the plants, especially the undersides of the leaves.

As the insects were invading the different plats in greater numbers and as showers had removed the spraying materials from the vines to a considerable extent, a second application was made on July 16. Heavy rains fell within the next ten days, which necessitated a third treatment on July 28. The last application was made on August 28. Subsequent observations indicated that the interval between the third and fourth treatments was too long because of the removal of the spray materials from the foliage thru the influence of the weather and the development of new growth which was exposed to the attacks of the insects.

PLATE VI.— EFFECTS OF ATTACKS OF LEAFHOPPERS ON POTATO FOLIAGE.

Plate VII.— Potato Leaves Protected from Injury by Leafhoppers.

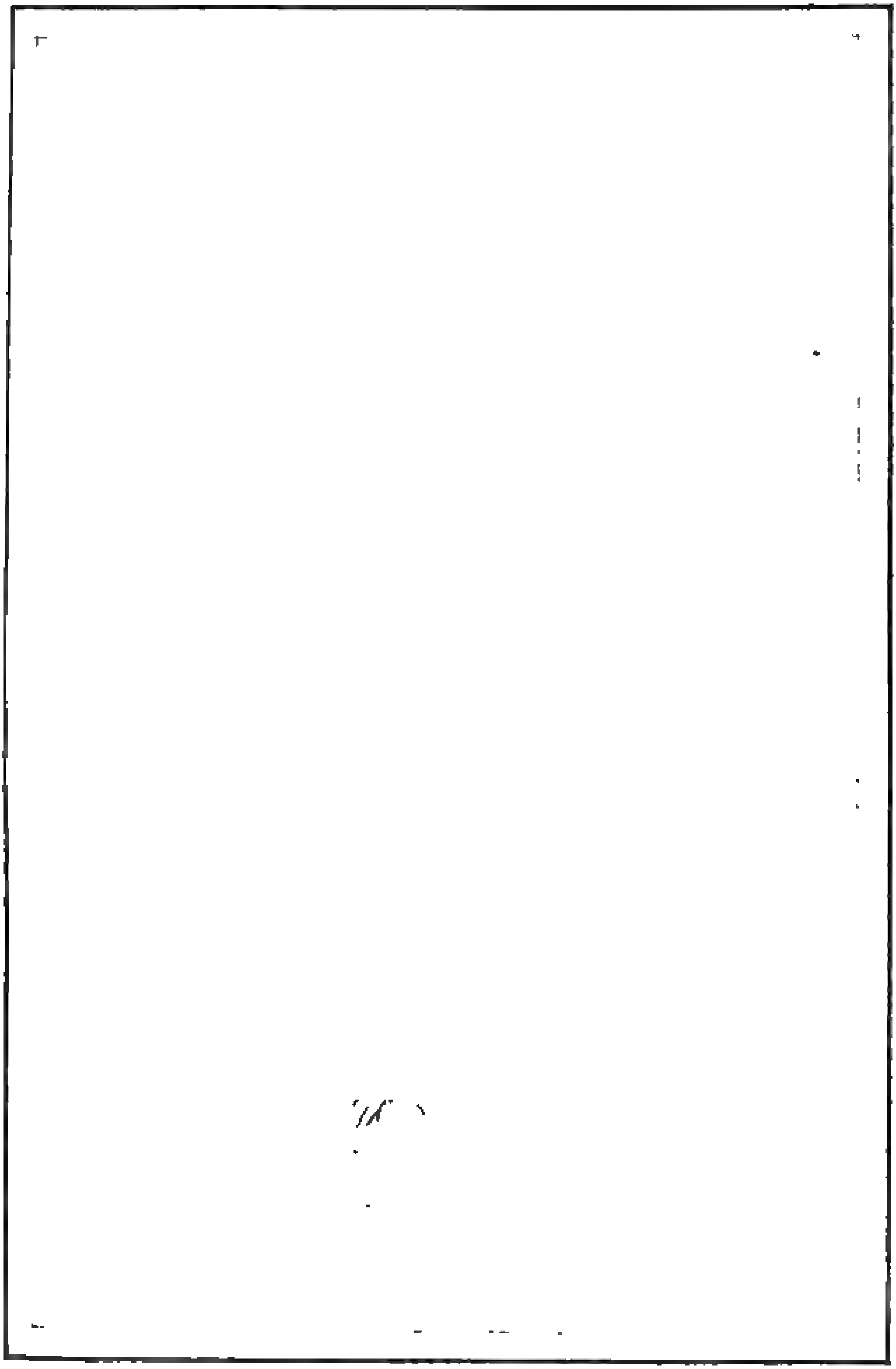


PLATE VIII.— A TYPICAL UNSPRAYED POTATO PLANT.

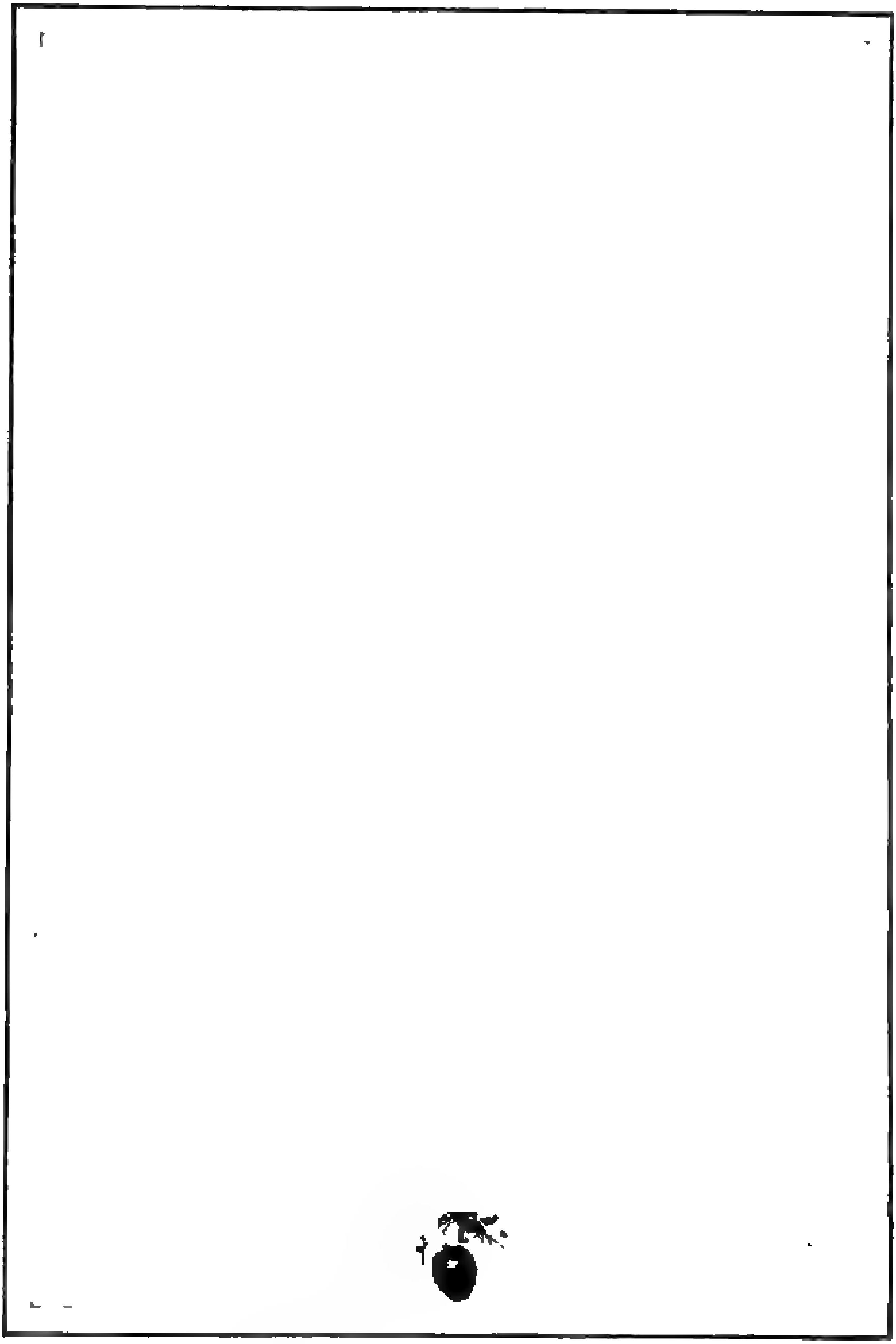


Plate IX.—A Typical Potato Plant from a Sprayed Plat.

In order to determine the effects of the different sprays upon the leafhoppers, counts were made of the adults at more or less regular intervals. The data are presented in Tables 1 and 2.

TABLE 1.— COUNTS OF LEAFHOPPERS ON SPRAYED AND CHECK PLANTS, 1919.

TREATMENT	DATE OF EXAMINATION											
	July 17	July 18	July 21	July 23	July 28	July 29	July 31	Aug. 1	Aug. 4	Aug. 13	Aug. 26	Sept. 3
Number of plants examined............	10	6	5	5	15	10	10	10	10	10	10	10
Check................	73	60	84	45	137	130	88	130	96	137	162	187
Bordeaux and lead arsenate............	37	29	34	29	51	54	31	33	48	45	34	29
China clay and soap...	29	15	30	32	33	10	12	12	10	15	24	18
Lime and bordeaux mixture............	30	23	45	35	19	12	8	14	13	15	39	15
Bordeaux mixture......	48	29	49	35	..	..	53	47	66	47	40	23

TABLE 2.— AVERAGE NUMBER OF ADULT LEAFHOPPERS PER VINE ON SPRAYED AND CHECK PLANTS, 1919.

TREATMENT	DATE OF EXAMINATION												
	July 17	July 18	July 21	July 23	July 28	July 29	July 31	Aug. 1	Aug. 4	Aug. 13	Aug. 26	Sept. 3	General average
Check..............	7	10	17	9	9	13	9	13	10	14	16	19	12.1
Bordeaux mixture and lead arsenate.	4	5	7	6	3	5	3	3	5	4	3	3	4.2
China clay and soap.	3	3	6	6	2	1	1	1	1	1	2	2	2.4
Lime and bordeaux mixture..........	3	4	9	7	1	1	1	1	1	1	4	1	2.8
Bordeaux mixture...	5	5	10	7	...	....	5	5	7	5	4	2	5.5

It will be observed from the foregoing figures that all of the spraying mixtures afforded considerable protection from the adults. More-

over, at no time during the season were the nymphs abundant on the treated vines, which was apparently due to the fact that the applications had repelled many of the adults and thus greatly reduced the amount of oviposition. Nevertheless, nymphs were observed on the vines, and during the latter part of August occasional burned tips were found in the sprayed plats, which will be discussed more in detail in subsequent paragraphs. This injury was attributed to the unavoidable postponement of the fourth spraying and, in all probability, could have been prevented or reduced in extent if one application had been made in early August and another during the latter part of the month.

The heavy washes, composed of china clay or lime, were somewhat more effective in repelling the insects than the other spraying mixtures. This was due to the fact that both of these sprays form a very thick coating on the leaves which proved unattractive to the insects. These two mixtures, in spite of their heavy consistency, caused very little trouble as regards clogging of the nozzles if the agitator of the spraying machine was efficient. In considering their merits as repellents it should be noted that china clay was more easily removed from the foliage by rains than any of the other mixtures, while lime applied in the amounts specified caused injuries to potato foliage which are indicated in Tables 6 and 8. The damage was first noted on July 28 when the third spraying was made, and after this date the injury increased considerably.

Because of its injurious effects on the leaves, the heavy lime-wash was the least satisfactory of the various mixtures tested. It is possible that preparations with smaller amounts of lime might prove equally effective against leafhoppers and less harmful to the foliage of potatoes. Altho bordeaux mixture alone or in combination with lead arsenate did not prove as effective a repellent as sprays of heavier consistency, it should be noted that thoro spraying of all surfaces of the plants prevented serious damage by the insects. Furthermore, this spray withstood the washing effects of rains much better than china clay or lime, the combination with lead proving somewhat superior to bordeaux mixture alone.

The distinguishing feature of the experiment was that during August the check plants showed burned tips and margins of the leaflets, while in early September they rapidly declined. At this latter date the sprayed vines presented in the main luxuriant foliage with only slight traces of injury, while the checks, in striking contrast to them, were inferior in size and had scanty foliage, which was to a large extent badly shriveled and brownish in appearance. (See Plates V, VI, and VIII.)

For the purpose of showing more clearly the injurious work of the leafhopper on potatoes, counts were made of sound and affected leaves on seventy-five plants from each of the plats. The data are given in Tables 3 to 8, inclusive.

TABLE 3.— LEAFHOPPER INJURY ON UNSPRAYED PLANTS, 1919.

NUMBER OF PLANT	LEAVES EXAMINED	LEAVES INJURED BY INSECT	EXTENT OF LEAF BURN BY INSECT		
			Slight	Moderate	Severe
	No.	*No.*	*No.*	*No.*	*No.*
1	49	34	6	8	20
2	78	52	8	10	34
3	103	34	10	6	18
4	59	24	16	2	6
5	71	36	4	12	20
6	78	45	8	8	29
7	155	96	42	20	34
8	40	18	2	6	10
9	82	31	5	7	19
10	163	55	15	10	30
11	95	41	12	18	11
12	94	62	8	9	45
13	127	46	11	7	28
14	171	97	16	12	69
15	118	62	10	8	44
16	134	64	7	12	45
17	167	107	13	30	64
18	211	91	20	11	60
19	78	28	5	7	16
20	300	142	30	17	95
21	223	191	41	50	100
22	190	71	15	16	40
23	170	87	14	20	53
24	115	60	13	15	32
25	89	47	6	7	34
26	109	57	15	7	35
27	55	53	16	10	27
28	80	54	14	8	32
29	37	22	4	8	15
30	69	25	3	4	18
31	48	40	10	16	14
32	40	23	4	5	14
33	74	42	6	6	30
34	85	52	20	12	20
35	74	52	9	8	35
36	48	34	13	7	14
37	91	36	10	8	18
38	92	56	8	20	28
39	52	28	5	10	13
40	91	73	18	30	25
41	38	22	4	8	10
42	67	44	15	9	20
43	91	31	10	9	12
44	49	18	6	5	7
45	98	62	16	20	26
46	100	47	20	13	14
47	72	36	9	15	12
48	55	26	10	3	13
49	64	28	7	12	9
50	148	41	23	10	8
51	111	62	12	30	20
52	62	17	4	4	9
53	72	24	9	10	5
54	66	36	8	8	20
55	59	23	10	7	6
56	42	19	5	4	10
57	78	28	10	6	12
58	52	24	5	6	13
59	63	34	13	10	11
60	49	28	4	4	20
61	57	25	4	5	16
62	105	47	16	20	11
63	78	39	8	9	22
64	48	25	5	6	14
65	65	30	9	9	12
66	38	12	2	3	7
67	81	28	6	8	9
68	80	38	14	5	19
69	64	31	9	4	18
70	64	40	12	10	18
71	70	44	14	12	18
72	108	49	9	15	25
73	95	64	15	15	34
74	78	44	5	18	26
75	30	13	2	3	8

TABLE 4.— LEAFHOPPER INJURY ON PLANTS SPRAYED WITH BORDEAUX MIXTURE AND LEAD ARSENATE, 1919.

Number of plant	Leaves examined	Leaves injured by insect	Extent of leaf burn by insect		
			Slight	Moderate	Severe
	No.	No.	No.	No.	No.
1	58	6	6	0	0
2	94	10	9	0	1
3	79	8	8	0	0
4	62	14	11	3	0
5	128	12	6	6	0
6	54	7	7	0	0
7	88	5	5	0	0
8	72	13	8	5	0
9	75	18	18	0	0
10	32	6	4	2	0
11	51	20	14	5	1
12	56	18	6	6	6
13	58	10	6	3	1
14	41	9	8	1	0
15	53	9	4	3	2
16	40	11	9	2	0
17	40	12	9	3	0
18	96	15	6	5	4
19	54	6	6	0	0
20	67	25	22	3	0
21	90	8	8	0	0
22	41	7	5	0	2
23	56	10	10	0	0
24	54	8	5	0	3
25	94	10	10	0	0
26	82	13	13	0	0
27	54	2	2	0	0
28	68	10	10	0	0
29	32	4	4	0	0
30	47	20	15	3	2
31	61	5	5	0	0
32	40	12	11	0	1
33	60	8	8	0	0
34	36	7	6	0	1
35	86	12	12	0	0
36	28	4	3	0	1
37	45	6	6	0	0
38	65	9	7	2	0
39	48	12	12	0	0
40	41	9	6	2	1
41	40	4	3	0	1
42	42	8	7	0	1
43	68	7	7	0	0
44	35	5	4	0	1
45	43	4	4	0	0
46	48	0	0	0	0
47	48	5	3	2	0
48	68	9	5	4	0
49	65	8	8	0	0
50	43	6	6	0	0
51	68	2	2	0	0
52	69	0	0	0	0
53	21	1	1	0	0
54	63	1	1	0	0
55	59	0	0	0	0
56	75	3	3	0	0
57	80	11	9	2	0
58	55	5	5	0	0
59	71	4	4	0	0
60	28	7	7	0	0
61	116	15	13	2	0
62	89	3	3	0	0
63	52	7	7	0	0
64	63	10	10	0	0
65	87	21	15	2	4
66	63	12	12	0	0
67	87	6	6	0	0
68	58	4	4	0	0
69	74	6	6	0	0
70	103	8	8	0	0
71	66	7	7	0	0
72	67	2	2	0	0
73	91	7	7	0	0
74	88	3	3	0	0
75	86	10	6	2	2

Table 5.— Leafhopper Injury on Plants Sprayed with China Clay and Soap, 1919.

Number of plant	Leaves examined	Leaves injured by insect	Extent of leaf burn by insect		
			Slight	Moderate	Severe
	No.	No.	No.	No.	No.
1	73	6	5	1	0
2	114	28	20	3	0
3	76	12	9	0	3
4	78	4	4	0	0
5	92	11	11	0	0
6	68	9	9	0	0
7	62	15	15	0	0
8	122	30	20	10	0
9	74	5	5	0	0
10	77	13	10	0	3
11	88	18	18	0	0
12	42	6	4	0	2
13	68	12	8	4	0
14	87	15	11	4	0
15	54	8	8	0	0
16	81	11	9	2	0
17	78	9	8	1	0
18	44	9	6	3	0
19	92	20	16	4	0
20	73	12	12	0	0
21	42	6	6	0	0
22	52	10	10	0	0
23	67	6	6	0	0
24	69	10	8	0	2
25	66	7	7	0	0
26	95	10	10	0	0
27	142	4	4	0	0
28	54	2	2	0	0
29	87	4	4	0	0
30	94	0	0	0	0
31	98	5	4	1	0
32	56	4	4	0	0
33	104	5	5	0	0
34	88	5	5	0	0
35	87	3	3	0	0
36	68	9	9	0	0
37	71	4	4	0	0
38	92	11	9	2	0
39	88	6	6	0	0
40	206	16	14	2	0
41	67	11	9	2	0
42	89	12	12	0	0
43	92	7	7	0	0
44	81	0	0	0	0
45	54	4	4	0	0
46	58	2	2	0	0
47	84	5	5	0	0
48	87	5	5	0	0
49	88	2	2	0	0
50	77	7	7	0	0
51	148	13	13	0	0
52	186	9	9	0	0
53	86	16	11	3	2
54	170	11	11	0	0
55	74	13	8	3	2
56	102	13	11	0	2
57	100	4	4	0	0
58	101	28	23	5	0
59	163	5	5	0	0
60	138	11	11	0	0
61	190	20	20	0	0
62	108	7	7	0	0
63	89	6	5	0	1
64	137	11	10	0	1
65	131	18	13	2	3
66	99	14	8	3	3
67	53	4	4	0	0
68	92	10	7	3	0
69	120	4	4	0	0
70	58	6	5	0	1
71	81	7	5	0	2
72	121	8	6	2	0
73	54	3	2	0	1
74	70	8	8	0	0
75	77	5	5	0	0

TABLE 6.—LEAFHOPPER INJURY ON PLANTS SPRAYED WITH LIME AND BORDEAUX MIXTURE, 1919.

Number of plant	Leaves examined	Leaves injured by insect	Extent of leaf burn by insect			Leaves injured by lime
			Slight	Moderate	Severe	
	No.	No.	No.	No.	No.	No.
1	115	10	7	0	3	30
2	120	43	31	0	12	9
3	45	9	9	0	0	7
4	113	5	5	0	0	16
5	83	7	5	2	0	10
6	94	8	4	0	4	27
7	78	10	8	0	2	30
8	82	4	4	0	0	8
9	62	5	5	0	0	18
10	92	10	8	0	2	28
11	67	7	7	0	0	14
12	77	10	10	0	0	28
13	71	5	4	0	1	10
14	75	8	8	0	0	18
15	71	9	6	3	0	9
16	128	14	14	0	0	25
17	81	10	7	3	0	9
18	91	11	7	4	0	16
19	60	20	18	2	0	5
20	72	7	5	2	0	11
21	71	8	5	3	0	12
22	116	14	10	4	0	25
23	58	12	12	0	0	7
24	52	8	8	0	0	21
25	83	9	9	0	0	15
26	93	5	5	0	0	15
27	93	5	5	0	0	18
28	63	3	3	0	0	12
29	72	18	18	0	0	8
30	118	6	6	0	0	16
31	91	7	4	3	0	19
32	108	8	8	0	0	13
33	59	4	4	0	0	10
34	69	6	6	0	0	11
35	47	5	5	0	0	10
36	47	4	3	1	0	12
37	79	6	6	0	0	24
38	130	2	2	0	0	15
39	47	5	5	0	0	9
40	78	5	5	0	0	14
41	80	4	4	0	0	17
42	67	6	6	0	0	9
43	51	0	0	0	0	9
44	68	3	3	0	0	17
45	46	3	3	0	0	10
46	103	4	4	0	0	14
47	76	4	4	0	0	7
48	45	2	2	0	0	6
49	41	1	1	0	0	16
50	63	2	2	0	0	13
51	89	7	7	0	0	19
52	112	12	12	0	0	14
53	108	8	8	0	0	24
54	130	5	5	0	0	24
55	63	5	5	0	0	11
56	123	3	3	0	0	16
57	108	14	14	0	0	25
58	172	8	8	0	0	26
59	188	7	7	0	0	23
60	122	5	5	0	0	38
61	103	4	4	0	0	18
62	80	3	3	0	0	12
63	74	2	2	0	0	18
64	98	5	5	0	0	18
65	51	3	3	0	0	8
66	89	0	0	0	0	19
67	63	2	2	0	0	14
68	224	13	13	0	0	53
69	92	5	5	0	0	16
70	100	2	2	0	0	13
71	103	9	9	0	0	4
72	80	2	2	0	0	10
73	72	0	0	0	0	13
74	75	10	10	0	0	18
75	97	3	3	0	0	15

TABLE 7.—LEAFHOPPER INJURY ON PLANTS SPRAYED WITH BORDEAUX MIXTURE, 1919.

Number of plant	Leaves examined	Leaves injured by insect	Extent of leaf burn by insect		
			Slight	Moderate	Severe
	No.	No.	No.	No.	No.
1	55	11	11	0	0
2	47	6	4	2	0
3	65	14	14	0	0
4	97	8	8	0	0
5	67	11	9	0	2
6	89	12	12	0	0
7	58	14	11	3	0
8	88	14	12	2	0
9	65	8	6	0	2
10	52	10	10	0	0
11	79	25	0	20	5
12	35	8	4	4	0
13	70	11	11	0	0
14	74	9	8	0	1
15	100	17	17	0	0
16	43	7	5	0	2
17	48	14	14	0	0
18	81	10	7	3	0
19	50	4	4	0	0
20	60	7	7	0	0
21	58	8	5	2	1
22	76	12	7	3	2
23	77	10	8	2	0
24	62	14	11	0	3
25	117	15	15	0	0
26	42	14	14	0	0
27	87	10	9	0	1
28	82	18	16	2	0
29	42	3	3	0	0
30	54	5	5	0	0
31	75	14	13	0	1
32	45	8	8	0	0
33	46	12	9	3	0
34	68	5	5	0	0
35	72	10	10	0	0
36	81	15	13	2	0
37	70	12	12	0	0
38	43	9	6	2	1
39	66	15	12	2	1
40	58	11	11	0	0
41	42	9	9	0	0
42	68	6	5	1	0
43	45	10	8	2	0
44	75	13	13	0	0
45	48	9	9	0	0
46	46	8	8	0	0
47	26	12	12	0	0
48	91	10	8	2	0
49	68	9	8	1	0
50	61	17	12	2	3
51	61	10	10	0	0
52	95	8	7	0	1
53	89	8	6	2	0
54	109	6	6	0	0
55	144	19	17	0	2
56	40	8	4	2	2
57	118	12	7	3	2
58	185	24	24	0	0
59	132	10	10	0	0
60	114	5	5	0	0
61	199	23	14	5	4
62	104	16	14	2	0
63	130	6	6	0	0
64	85	2	2	0	0
65	48	4	4	0	0
66	80	12	9	3	0
67	77	5	5	0	0
68	80	7	7	0	0
69	76	2	2	0	0
70	83	5	5	0	0
71	78	12	10	2	0
72	73	5	5	0	0
73	107	10	10	0	0
74	42	7	7	0	0
75	45	6	4	0	2

TABLE 8.—LEAFHOPPER INJURY ON SPRAYED AND UNSPRAYED PLANTS, 1919.
Summary of Tables 3 to 7.

TREATMENT	LEAVES EXAMINED	LEAVES INJURED BY INSECT		EXTENT OF LEAF BURN BY INSECT			LEAVES INJURED BY SPRAYING MIXTURES
				Slight	Moderate	Severe	
	No.	*No.*	*Per cent*	*No.*	*No.*	*No.*	*No.*
Check.............	6711	3442	51	822	812	1808	00
Bordeaux mixture with lead arsenate.	4655	621	13	518	68	35	00
China clay and soap.	6794	684	10	596	60	28	00
Lime and bordeaux mixture..........	6403	518	8	467	27	24	1201
Bordeaux mixture...	5617	775	14	658	79	38	00

While chiefly of value in indicating the destructive capacity of the leafhopper as a potato pest, Tables 2 and 8 also clearly show that injuries to foliage varied in amount as well as in degree according to the severity and period of duration of infestation.

REPORT

OF THE

Department of Horticulture

U. P. Hedrick, *Chief in Research (Horticulture).*

O. M. Taylor, *Associate in Research (Horticulture).*

F. E. Gladwin, *Associate in Research (Horticulture).*
(Connected with Grape Culture Investigations.)

G. H. Howe, *Associate in Research (Horticulture).*

Richard Wellington, *Associate in Research (Horticulture).*

W. C. Stone, *Assistant in Research (Horticulture).*

E. H. Francis, *Assistant in Research (Horticulture).*

T. E. Gaty, *Assistant in Research (Horticulture).*

T. O. Sprague, *Assistant in Research (Horticulture).*

H. B. Tukey, *Assistant in Research (Horticulture).*

TABLE OF CONTENTS

REPORT OF THE DEPARTMENT OF HORTICULTURE

STUDIES ON THE COST OF PRODUCING GRAPES*

F. E. GLADWIN

SUMMARY

Detailed information has been accumulated regarding the cost of producing grapes in three widely separated vineyards of the Chautauqua and Lake Erie fruit belt for the period of 1915 to 1919, inclusive.

Data are presented which show the amounts expended for maintenance, labor, and harvesting for each vineyard as well as for each acre cultivated and for each ton of grapes produced. The net return per acre and per ton is estimated for each year of the investigation

The average cost of production for the three vineyards during the five years was $74.13 per acre, and the average cost per ton of grapes was $40.58.

The average net profit per acre was found to be $66.64, and the average profit per ton $26.31.

It is concluded that under intensive management the growing of grapes in this region can be made profitable, in spite of the high cost of labor and supplies, providing the selling price of the crop is maintained at or near the level of the 1918 and 1919 seasons.

INTRODUCTION

There has long been a need for definite information regarding the cost of producing grapes. In view of the wide difference of opinion that has arisen between producers and the large users of grapes as to what constitutes an equitable price, it would seem that figures showing the cost of production might serve to bring about a better understanding between the interests involved. The uncertain demand for manufacturing purposes from year to year tends to make the selling price of the crop very unstable, and this in turn is reflected thru the whole industry.

Accurate data covering farming costs have been most difficult to obtain. In general, the returns have sufficed if they have been

* Reprint of Bulletin No. 479, September, 1920.

sufficient to pay the obligations incurred in growing the crop. In many instances, however, the returns have not paid even the cost of production, when a proper valuation is given to the labor of the grower and his family.

As vineyard practices vary greatly with growers in the same locality, any set of figures will represent the outlay only for vineyards operated in like manner. Data obtained in 1909 from an interview with some 500 growers in the Chautauqua and Lake Erie fruit belt showed that but few grape-growers operate their acreages in a similar manner. These data further indicated that the methods used differ most in fertilizing practice and in tillage. The investment in posts, wire, tools, etc., varies from year to year in the same vineyard, and to a much greater degree in different vineyards in the same locality. Posts deteriorate more rapidly in some soils than in others.

While many growers spray as a regular vineyard operation, the great majority have never done so.

Pruning, altho it must be done each season, is a variable factor because of the methods followed in previous seasons. The extent and location of the new growth affects materially the speed of the pruner. Tying, while fairly uniform from year to year, is nevertheless influenced by the number of fruiting canes to be put up.

The length of life of a well cared-for vineyard in this locality is not definitely known, but it is evident that it is not so short as ordinarily supposed. Several productive plantings are known that have been set for 40 years, and are still good for many years to come. Again, other plantings under the best of care fail after yielding a few crops. Between these extremes lie the bulk of the vineyards, varying in length of life and productiveness up to the twentieth year when they fail quite rapidly. Unfavorable soil conditions, depleted fertility, over-cropping, and infestation of the grape-root worm — all play their part in deterioration.

A study of many vineyards indicates that they should be in their prime at from six to twenty-five years of age. Unlike some of the tree fruits, the life of the vine cannot be accurately divided into periods or epochs, for the bearing age is reached early and, under favorable conditions, uniform crops will be produced for a number of years. The fruiting wood of the vine is not allowed to accumulate

from year to year as with tree fruits, the requisite number of buds for satisfactory crop production being obtained the third or fourth year after planting.

The data herein presented cover a period of five years, 1915–1919, for three vineyards located in widely separated parts of the Chautauqua and Lake Erie fruit belt. The results are, therefore, only an indication of the outgo and income from acreages worked in a similar manner, and for that reason have a somewhat limited application. It is realized that the expenditures in two of the vineyards are probably in excess of those for the majority of vineyards in this section or in any section of New York.

EFFECT OF CLIMATIC CONDITIONS

Unfavorable climatic conditions during two of the five years under discussion influenced the labor and the crops in these vineyards. The low yields of 1916 and 1918 are directly attributable to the weather of the preceding fall and winter of each year. However, the five-year period differed no more in this respect than did the five years immediately preceding; and if the partial or complete crop failures for the past 20 years are taken into consideration, it is probable that the same ratio would be maintained. In one of the vineyards, work was seriously interfered with by prolonged rains, while many tons of grapes were unharvested in 1917 due to unseasonably low temperatures. Such climatic hazards should receive consideration in determining the selling price of grapes.

DESCRIPTION OF THE VINEYARDS

VINEYARD E

Vineyard E contains about 20 acres and is located on Dunkirk clay to clay loam soil. The acreage lies immediately adjacent to Lake Erie and has been planted approximately 20 years. It is typical of the vineyards in the locality, except that it has had better care. The soil is inclined to be wet, and this has interferred at times with cultural practices. Periodic infestations of the grape-root worm have occurred. This vineyard is probably more representative of the vineyards found in the Chautauqua and Lake Erie fruit belt than the other two.

VINEYARD S

Vineyard S consists of six acres about equally divided on two soil types, Dunkirk clay loam and Dunkirk gravelly loam. The part situated on the clay loam has been planted about nine years, while the portion on the gravelly loam is approximately thirty years old. Both areas had been consistently manured or fertilized with commercial materials for several years before the cost data were recorded, and likewise annually since the beginning of the tabulations. The pruning, tillage, and other practices have varied somewhat from year to year, but it is believed that these operations have been performed more uniformly than in the average vineyard. However, there are many vineyards that have had equally as good care, and there are perhaps some that have had more thoro tillage and heavier applications of manure or fertilizer. Soil variations that are common to most acreages of any extent in this section are present in Vineyard S to a much greater degree than in the other two vineyards. The older portion was of average productiveness for the soil type 10 years ago. The younger portion, on the clay loam soil, was tile drained one year previous to planting in 1910, with a regular system of laterals two rods apart opening into two mains. The older portion is naturally well drained, the soil possibly being too open for seasons of drouth.

VINEYARD R

Vineyard R contains approximately eight acres and is situated on Dunkirk clay to clay loam soil. A large part of the acreage was tile drained after planting so that no regular system was followed, but rather the lines of tile were located so as to tap the low areas. The vines are approximately 15 years old but, due to indifferent care before the present owner took possession, they have the appearance of being considerably younger. From information in hand it would seem that this vineyard could not have been a very profitable one as many vines had died early and no re-planting had been done. Infestations of the grape-root worm had also greatly reduced the viatlity of many other vines, so that the present owner has been at considerable expense in re-establishing the dead and missing vines. This vineyard can now be rated above the average for those of the locality altho it was probably but average or below a few years since.

CHARGES FOR INTEREST AND LABOR

At the beginning of the cost accounting work it was agreed that certain uniform sums should be charged for the various items of work, as well as for maintenance. It was also decided that as vineyards similar to the ones under consideration were being sold at $300 per acre, this valuation would be a fair one on which to figure the investment in land. It was agreed that interest on investment should be fixed at 6 per cent.

In 1915, while team and man could be hired for $4.00 per day, it was decided to charge $5.00 in order to cover investment, upkeep, and depreciation on horses and tools. The rate for a single horse and man was fixed at 35 cents per hour, while day labor was charged at the rate of $2.00 per day.

The rates have of course increased greatly since these figures were established, and while Vineyards E and R met the advances from year to year, the rates actually paid for the working of Vineyard S did not rise until 1918. The reason for this was that a long time contract was made at stipulated prices. The maximum was reached with Vineyard S in 1919, when the rate for team and man rose to $6.00 per day. However, even this advance does not conform to the rates paid in Vineyards E and R. In studying the cost sheets for Vineyard S these facts should be kept in mind, for were the rates that have been paid in Vineyards R and E figured against Vineyard S, the production costs would be somewhat higher for the years 1918 and 1919 than is indicated. It was deemed best to present the actual expenditures for this vineyard rather than to assume that the rates were the same as those prevailing in the other two vineyards.

The rates for Vineyard E advanced in 1918 to 60 cents per hour for team and man, to 45 cents per hour for single horse and man, and to 30 cents per hour for day labor. In 1919 the rate for team and man advanced to 70 cents per hour, for single horse and man to 50 cents per hour, and for day labor to 40 cents per hour. The owner of this vineyard used a tractor for part of the work in 1918 and 1919. He states that he accomplished twice the amount of work in a given time with the tractor as with a team. Hence, the use of the tractor has been charged at the rate of $1.20 per hour for 1918, and at the rate of $1.40 per hour for 1919. The figures include the operator.

As previously stated, the rates for team and man hire in Vineyard S remained as they were agreed upon in 1915 until 1919, when the

rate for team hire was raised to $6.00 per day and for a single horse and man to $4.50. The day labor rate advanced to $2.50 per day in 1917, and to $2.75 per day for 1918.

The rates paid by Grower R remained practically as decided upon until 1917, when he was obliged to pay $8.00 per day for team and man, $4.00 per day for a single horse and man, and $3.00 per day for day labor. In 1919 the single horse and man rate advanced to 60 cents per hour and day labor to $4.00 per day.

Since pruning is a more specialized work, it has been charged at a higher rate than day labor for all three vineyards. During the five years the increase has ranged from 5 to 10 cents per hour more than was paid day labor.

Women are usually employed for spring tying and for picking the crop. The rates that have been paid for this work have varied from 15 cents per hour in 1915 to 30 cents in 1919. The proximity to large centers of population tended to keep the rates lower than those paid in more remote localities.

DISCUSSION OF PRODUCTION COSTS IN VINEYARD E

MAINTENANCE

In Table 1 are given the costs of maintenance and upkeep of the 20 acres comprising Vineyard E for the five year period together with the five year averages.

It may be seen from this table that, aside from the interest charge on the investment in land, the expenditures for maintenance varied greatly from year to year. For example, the amount spent for fertilizer and manure in this vineyard ranged from $39.86 in 1915 to $213.40 in 1918. The larger expenditure in the latter year was due directly to the use of a larger amount of farm manure and commercial nitrogen. It is also evident that the money spent for posts, wire, tools, etc., has varied considerably during the five years. A part of the variation is probably due to a surplus of the supplies purchased in a previous year. The rate of post deterioration is somewhat dependent on the nature of the season as well as on the quality and seasoning of the posts. In 1918 the vineyard was seeded to hairy vetch and rye at the last cultivation, hence the charge of $114, or $98 more than was spent in any other year for the same purpose.

In Table 2 the costs for Vineyard E have been reduced to an acre basis. It is at once apparent that the interest charge of $18.00 is the largest single cost item involved. The average cost of manure and fertilizer, $6.31, is second in amount. This average certainly cannot be considered excessive, and it is probable that the average vineyardist has a larger annual investment in one or the other of these items. From a study of the totals for any season, it will be seen that the greatest variation has been about $13.54. In other words, it cost this extra sum for maintenance in 1918 as compared with the minimum of 1915. A consideration of the table shows that this grower spent annually on the average of $29.56 for interest, taxes, and supplies.

In Table 3 the costs have been further reduced to a charge against each ton of grapes actually produced in the vineyard. A large percentage of the grapes grown in this region is sold by the ton and it is on this basis that the selling price is fixed. The costs for growing grapes when figured on the ton as a unit are naturally as variable as are the yields from year to year, and as no two vineyards yield exactly the same, the tonnage production costs will vary in each. A consideration of this table shows that in 1915 a ton of grapes was charged $5.92 as its share of the interest on the investment, and that on account of the low yield of 1918 each ton of grapes bore a charge of $30.00 for this item. Again in 1915, each ton was assessed 64 cents as a fertilizer and manure charge, while in 1918 each ton represents an investment of $17.78.

If the same amount was invested each season for the different items, and if the tonnage per acre was uniform, then ton production costs would be the same from year to year. However, the tables show that these conditions are not met and it is to be noted that a high yield means low ton production cost, while a light crop entails a larger production charge. By consulting the totals for maintenance for the several years it is seen that maintenance cost the least per ton in 1915, when a crop of three tons per acre was produced, and that each ton cost the most in 1918 when the lightest yield of the five years was harvested. The five year average of $24.41 probably represents the investment of the majority of the growers in this section for maintenance. As most of the expenditures influence the crop for more than the season in which the investment is made,

it would seem that the average for the five years is a better index to the cost of maintaining the vineyard than the cost for any one year.

LABOR

Table 2 shows that, considering collectively the various operations, the tillage item was the largest in the labor costs. The amount invested per acre for this purpose ranged from $4.05 in 1917 to $12.40 in 1918. The average for the five years amounted to $7.03. The climatic conditions which prevailed in the spring and thruout the growing season greatly influenced tillage operations. At this time scarcity of labor is another controlling factor.

Pruning was the second largest item of expense. The range for this work from year to year does not equal that for tillage. The varying amounts may be attributable to a greater or lesser quantity of wood to be pruned away, to the skill of the pruner, or to the wage paid. The average of $3.44 for the five years approaches the average expense for many vineyardists. It is further seen from the five year averages of Table 2 that it has cost about the same to clear the pruned wood from the wire and to dispose of it as it has to repair the trellis. Attention is directed to the marked uniformity of the total labor expense for the years 1915, 1916, and 1917, and again to that for 1918 and 1919. The higher costs of the latter two years are probably due to the higher cost of man and horse labor.

Reference to Table 3 discloses the fact that the highest labor charge against each ton is for tillage. In 1915 each ton of grapes produced cost $1.65 for tillage, while in 1918 each ton had to bear a charge of $20.66 for this item. A comparison of this table with Tables 4 and 7 indicates that the tillage of Vineyard E has not been as intensive as that of Vineyards R and S. The average tillage cost for the five years, $6.67, is probably more representative of the usual expenditure for this purpose than is that of Vineyards R and S. It should be noted that, as in the case of maintenance, the higher yield reduces the labor charge against each ton and that low yields increase the charge. In other words, it cost but $4.47 for labor in producing a crop of three tons of grapes per acre in 1915, while in 1918, when only 0.6 ton was harvested, each ton cost $36.14. The same correlation holds for the other years of the period under discussion.

UPKEEP

Table 2 gives the upkeep expense per acre for each of the five years and the average for the period. The amount involved ranged from $36.54 in 1915 to $58.04 in 1918. The reduced expenditure for fertilizer in 1919 as well as the omission of certain tillage operations, lowered the expense of upkeep for that season as compared with 1918. The difference in upkeep costs between the seasons of 1917 and 1918 is probably due in part to the higher rates of the latter year. It is seen that in this vineyard it has cost on the average $47.28 per acre to bring the crop to the harvest stage.

When Table 3 is studied, the influence of the size of crop on the total upkeep expense assessed against each ton is further emphasized. In other words, each ton of grapes produced in 1918 cost more than eight times the amount that each ton cost is 1915. It will be seen that between these extremes, ton production cost is quite proportional to yield. The average cost of $38.96 assessed against each ton for the five years is an indication of what the grower should receive on his investment.

HARVESTING

Harvesting expenses fluctuate considerably with the size of the crop and with the manner in which it is handled, whether in crates or baskets. It costs less to pick in crates and handle subsequently than to harvest in 12 quart baskets, the smaller packages incurring a still higher cost. Within certain limits it costs just as much to harvest a small crop as one considerably larger, but as the difference between yields becomes wider the cost of handling becomes higher.

From Table 2 it is seen that the charge per acre for harvesting varied from $8.65 in 1917 to $17.12 in 1916 or approximately twice as much. In this instance the tonnage yield per acre in 1916 was about double that harvested in 1917. The crop of 1918 was only half as large as that of 1917, and yet it cost $1.27 more to harvest it. It has cost on an average of $13.16 to harvest the crop from an acre in this vineyard, the average production of which has been 1.81 tons per acre for the five years. This cost seems high but when it is considered that this charge includes hauling, handling, and covering the packages it is not excessive.

A study of Table 3 shows that it has cost from $4.27 to $16.53 a ton to harvest the grapes of this vineyard during the past five years. A grower with a large acreage kept cost accounts over the period of 1908–1912, inclusive, and found that it cost $4.00 to harvest a crop of one ton per acre during these years, and that this cost was increased if the fruit was graded as picked. The higher labor rates are reflected in the costs of 1918 and 1919. The average cost for the five years, $8.96, for picking and hauling a ton of grapes, does not appear excessive in view of the higher labor and horse rates that have been paid in recent years.

TOTAL COST OF PRODUCTION

Table 2 shows that it has cost from $49.54 to $68.01 per acre to pay the interest charge, taxes, and insurance, to purchase supplies, and to provide the labor for growing and harvesting the crop in vineyard E. It is also evident that the total acre production costs were highest in 1918 and 1919, and that the amounts for these years were practically the same. The average for the five years, $60.44, is probably less than that for vineyards of which this one is typical.

In these figures no account has been taken of the cost of vineyard equipment, depreciation, and repairs. The Department of Farm Management at Cornell has found that under pre-war conditions such costs averaged about 5 cents per horse hour, and also that it has probably doubled since that time. Using the average of 7½ cents per hour, and multiplying by 24 horse hours, the number given to each acre as the average for the five years, it is found that $1.81 should be added to the acre production cost of $60.44.

No data are available as to what should be charged for upkeep and depreciation on the tractor. However, if it be assumed that the one owned by this grower cost $1200 and that its life is eight years, then the depreciation would amount to $150 annually. There are approximately 90 days during the season that a tractor may be used in farm work. If the above figures are reduced to depreciation per hour, there should be charged off about 17 cents for each hour the tractor was used. As the tractor was used but little in vineyard work, only $1.35 should be added to the total acre production cost. The yearly acre average for this vineyard then is raised to $63.60.

Reference to Table 3 shows that the total cost of production per ton varied from $16.24 in 1915 to $113.24 in 1918, or in other words,

it cost seven times more to produce a ton of grapes in 1918 than in 1915. It is interesting to note that from 1915 thru 1918 the yields per acre have declined and that the total ton production costs have increased. The effect of increased tonnage on production cost is noted from a comparison of the figures of 1918 and 1919. In 1918 the peak of high cost was reached. The average ton production expense over the five years is seen to be $47.92. This figure at first glance seems to be high, but reference to cost figures from another extensive acreage confirms this total.

NET RETURN

A study of Table 2, which gives the tons produced each year, the selling price, and the net profit per acre, discloses the fact that this vineyard has yielded a profit in three of the five years ranging from $40.14 per acre in 1915 to $96.75 in 1919. It is further evident that in two years a loss has been sustained and that the highest selling price was obtained in one of these years. It is indicated by these figures that the selling price is not proportional to the yield nor to the cost of production but rather seems to be a hit or miss figure. It is further evident that the money return from acreages of low yield is not proportional to the size of the crops as is generally supposed.

Table 2 shows that an average annual profit of $39.30 per acre was secured over the five years. With an investment in land of $300 per acre, Vineyardist E has made 13 per cent as the average of the five years. It certainly cannot be claimed that this grower has profiteered, for considering the uncertainties of farming in general and grape growing in particular, he should not be expected to conduct his business on a profit basis of less than 20 per cent.

Table 3 presents the net profit for each ton of grapes grown and sold at the market prices prevailing for the several years of the investigation. In 1917 each ton of grapes sold at $2.35 less than it cost to grow them, while in 1919 each ton netted $57.79. It is emphasized further that no correlation has existed between yield and selling price. The table shows that the average profit for each ton of grapes over the five years has been $18.56. If the average yields for the period had been 4 or 5 tons per acre, the returns could be considered satisfactory, but as this vineyard has averaged only 1.8 tons, the owner cannot profitably continue on the same basis

as he has in the past. The average tonnage for the entire " Belt " for the past several years is considerably less than 1.8 tons, hence the gain from many vineyards, unless their production costs have been considerably lower than in this vineyard, must have been less than that obtained by Grower E.

DISCUSSION OF PRODUCTION COSTS IN VINEYARD S

MAINTENANCE

Figures showing the costs of maintenance, labor, upkeep, and harvest for the 6-acre Vineyard S for each of the five years are given in Table 4, together with the five year averages for each of the items. The charges are reduced to an acre basis in Table 5 and to cost per ton in Table 6.

In this vineyard, as in Vineyard E, the interest on the investment in land has been the largest single annual expenditure for maintenance, and the cost of fertilizer second. While the rate for borrowed money remained the same for the five years, Table 5 shows the advance in price of the fertilizer elements. In 1915 the amount invested in fertilizer for each acre was $11.31, while in 1919 the same amount of like materials cost $19.16. The rather low charges for posts, wire, tools, staples, etc., are due, in large part, to the fact that one-half of this acreage is of recent planting, hence the trellis has not required much repair. The variation in the cost of green-manure seed is largely attributable to the different crops employed for this purpose, except that the greater cost for 1919 over 1918 is due to the higher selling price of seed for that year. The increased charge for spray materials in 1918 represents the advance in cost of the materials used. The marked uniformity of the totals for the seasons of 1915, 1916, and 1917, and for 1918 and 1919 is worthy of note. The total maintenance expense for the first three years varied by $3.86, while the totals for 1918 and 1919 varied by but 43 cents. However, had spraying been done in 1919, the maintenance for that year would have increased this difference.

It is clearly evident from a study of the figures given in Table 6 that the cost per ton of producing grapes was little affected by fluctuations in the cost of materials, but rather by differences in yield. The charge for maintenance in 1918 shows the effect of low yield on the cost of each item under this heading. In the case of

the 1915, 1917, and 1919 crops which varied within 0.1 ton, the cost for maintenance in 1917 was just $1.27 and in 1919, $2.91 more per ton than in 1915. It is plain, therefore, that the investment for maintenance was quite uniform. The average annual charge per ton for maintenance was $21.05.

LABOR

As with Vineyard E, tillage has been the heaviest charge in the labor accounting in Vineyard S altho the cost for tillage in the latter has not fluctuated as greatly as in the former. Thus, in 1915, $10.22 per acre was expended for this purpose while in 1919 the charge was $9.37 per acre. Tillage operations in this vineyard have been governed largely by the frequency of rainfall. As a consequence, even tho the rate per hour charged for labor has increased in later years, weather conditions, especially as to rainfall, have in part counterbalanced the increase. This vineyard also has been given the same general tillage aside from harrowing, year in and year out, and this has tended to keep uniform the tillage cost.

The cost for pruning takes second rank in the labor charges, and here the annual variation has been considerable. In large part the increased costs of 1918 and 1919 are due to the higher rate paid for labor in these years. The five year average of $4.25 per acre is probably higher than for the average vineyard.

Considering the total labor expense for each of the five years, it is seen that a very similar amount was invested in 1915, 1916, and 1917, while the variation for the years 1918 and 1919 was only about $2.00.

Reference to Table 6 shows that a total of $11.63 was spent for tillage in 1918 for each ton of grapes produced, while only $2.25 was invested for this purpose in 1917. In 1918 it cost $5.82 per ton for pruning, while in 1915 the amount chargeable against each ton was but 88 cents. The labor expense per ton has varied from $5.63 in 1915 to $25.62 in 1918, while the average for the five years was $10.86.

UPKEEP

According to Table 5, the cost of upkeep per acre in Vineyard S ranged from $58.51 to $73.74. It should be noted that this item varied but little in 1915, 1916, and 1917, and likewise that the cost for the years 1918 and 1919 varied by only $1.66. The average

of $65.56 for the five years represents the total invested in upkeep per acre for this vineyard. The total upkeep chargeable against each ton of grapes produced, as shown in Table 6, varied considerably over the period studied, the amount ranging from $17.23 in 1915 to $71.56 for 1918. Attention is directed to the uniformity of this item for the years 1915 and 1917 when the yields varied by but 0.03 ton. The average annual cost of upkeep per ton of grapes was $31.91.

HARVESTING

Table 5 shows that it cost from $8.41 to $26.98 per acre to harvest the crop from Vineyard S. Reference has already been made to factors other than variations in yield which influence the cost of harvesting. If these factors remained constant, a study of harvest cost would mean much more than is here indicated; however, a consideration of this item on the basis of costs per ton is fairly suggestive. In Table 6, it is seen that this charge was highest in 1918 and 1919, while that for 1915 follows, with the cost for the years 1916 and 1917 ranking lowest and being quite uniform. The higher cost for harvesting in 1915 is directly attributable to the package used while that for 1918 and 1919 was due wholly to the increased wage paid during those years. The average annual cost per ton to harvest grapes from this vineyard was $6.82.

TOTAL COST OF PRODUCTION

An examination of Table 5 shows that it cost from $72.59 per acre in 1916 to $99.06 in 1919 to grow and harvest the crop in Vineyard S. The average cost of production for the five year period was $83.22. Data kept by careful growers, covering several years up to and including 1912 show that it cost from $55.00 to $60.00 to produce the crop from an acre of grapes.

The total cost of producing a ton of grapes as shown in Table 6 was lowest in 1917 at $23.75, and highest in 1918 at $79.72. The years of fairly uniform tonnage, 1915, 1917, and 1919, likewise show a quite uniform cost of production per ton. Each ton of grapes harvested in this vineyard cost on the average $38.73 for the five year period.

NET RETURN

Vineyard S produced a profit on the investment in each of the five years, altho the gain has been quite variable. Reference to

Table 5 shows that the smallest net gain per acre was received in 1915, and amounted to \$19.13; while the maximum gain was realized in 1919 and amounted to \$227.48. The highest price per ton was paid in 1918 but the low yield of that season reduced the profit per acre to a little more than one-half that of the previous year with a yield three times greater and a selling price of three-eighths that of 1918. This again emphasizes the fact that low yields, even if sold at apparently high prices, do not give the returns realized from medium to above medium yields sold at considerably lower prices. In 1919 the tonnage per acre produced in Vineyard S was relatively high and, with a selling price of \$99.25, a very satisfactory profit was realized. However, as large buyers of grapes usually fix their purchase price on the average supply in sight, without regard to the cost of production, the yearly profit becomes problematical.

From Table 6 it will be seen that each ton of grapes grown in 1915 sold at a profit of \$5.68, not an encouraging return. The profit per ton increased regularly from that year thru 1919 when the maximum profit of \$69.12 was received. However, the average profit of \$27.85 per ton realized for the five year period would not seem large enough to stimulate the grower to increase his acreage materially, especially in view of the mounting cost of supplies and the scarcity of labor. The average tonnage per acre for the five years is somewhat higher than for vineyards situated on similar soil and under good cultivation, so that the profits from Vineyard S are probably in excess of the returns from many vineyards, altho some have done better.

DISCUSSION OF PRODUCTION COSTS IN VINEYARD R

MAINTENANCE

The data covering Vineyard R are found in Tables 7, 8, and 9. In Table 7 the total costs for maintenance, labor, upkeep, and harvest are given for the entire 8 acres. In Table 8 these figures are reduced to the acre basis, while in Table 9 the figures represent the charge against each ton of grapes produced.

It will be noted from Table 7 that, aside from the interest charge, the items for maintenance have been quite variable. The fertilizer charges have been very irregular except in two of the five seasons,

but the greatest variation has occurred with such supplies as posts, wire, etc. However, as previously stated, the cost of items of this character should be considered only over a period of years as a large expenditure for them in one season lessens the cost for one or more years following. The practice of replacing vines has been followed consistently, and the higher amount spent for this purpose in 1919 is in large part due to the increased selling price of grape roots.

From Table 8 it will be noted that, aside from the interest charge, the cost for fertilizer, manure, etc., has been the largest expenditure per acre over the five years, and that closely following this is the charge for taxes and insurance. The minimum investment for maintenance has been for green manure seed due to the fact that this practice has been omitted in two of the five years.

A study of Table 9 shows that the maximum charge for maintenance for each ton of grapes produced occurs in 1918 and the minimum charge in 1919. The greater yield in the latter year reduced the sum charged against each ton and in spite of higher rates for supplies, the maintenance cost was reduced. The total cost of maintenance for the years 1915, 1916, and 1917 varied but little due to the fact that quite similar yields were harvested during these years.

LABOR

Reference to Table 8 shows that of the money invested for labor by far the greater amount was spent for tillage. The minimum charge of $7.86 was paid in 1917, while the maximum of $16.75 was invested in 1919. The increased amounts paid in both 1918 and 1919 are directly attributable to higher rates of man and horse hire in these years. It cost approximately equal amounts per acre to prune, dispose of the pruned wood, and keep the trellis in repair over the five year period. As spraying and green manuring were practiced irregularly, the cost of these operations was very small.

In Table 9, where the charges are reduced to the cost per ton of grapes, it is seen that the minimum expenditure for labor was in 1917 when each ton bore a charge of $7.33, while the maximum charge of $26.94 occurred in 1918. As already noted, more money per acre was spent in 1919, yet with a greater production than in any of the five years the per ton cost was reduced very nearly to the average level of former years of lower labor rates. It has cost $12.33 per ton for labor as an average for the five years. This is probably

rather low for the average vineyardist since the yields in this vineyard have been consistently higher than those secured in this region.

UPKEEP

The total upkeep expense per acre for Vineyard R ranged from \$48.66 in 1916 to \$74.75 in 1919, while the average for the five year period was \$60.41. The maximum upkeep per ton was \$55.19 in 1918, the year of minimum yield, while each ton cost the minimum of \$18.98 in 1917. Each ton cost on an average of \$27.40 for the five years.

HARVESTING

The cost per acre for harvesting the crop from this vineyard (Table 8) ranged from \$12.10 in 1916 to \$29.47 in 1919 when the maximum yield for the five years was secured. It is interesting to note that it cost more to harvest the 1918 crop which was the lowest for the period, than it did to harvest the 1915 or 1916 crops which were more than twice as large. As previously noted, the containers used in 1918 may have been partly responsible for this difference.

From Table 9 it is seen that the cost per ton of harvesting the crop varied from \$4.90 in 1916 to \$12.58 in 1918, and furthermore that the cost in 1919 was but slightly higher than in 1917, altho the yield was a ton per acre greater. It has cost on the average for the five year period \$7.69 to harvest a ton of grapes.

TOTAL COST OF PRODUCTION

The total cost of production per acre (Table 8) in Vineyard R ranged from \$60.76 in 1916 to \$104.22 in 1919. Aside from the low cost for 1916 and the high figure for 1919, the expenditures have been remarkably uniform for the other years. The total cost of production per acre averaged \$78.74.

Table 9 shows that the lowest cost of production per ton occurred in 1916, while the highest cost was in 1918, the year of lowest yield. Attention is directed to the marked uniformity of costs for the years 1915, 1916, 1917, and 1919. The average for the five years, \$35.09, should form some basis for fixing the selling price in the future for, during the past ten years, grapes have sold for considerably less than this figure.

NET RETURN

Vineyard R has returned a net profit per acre (Table 8) each year ranging from $26.80 in 1915 to $249.18 in 1919. The greatest profit was derived in the year of maximum yield for the period, altho the selling price for that year was less than for the previous season. The five year average of $86.76 has returned to this grower a very satisfactory profit per acre; and if the business were larger, the income therefrom would be sufficient to meet the needs of the average family in normal times.

Table 9 shows that the minimum profit per ton was secured in 1915 when the minimum price of the five years was paid. The maximum profit was obtained in 1919 when the largest yield was secured and when the average selling price of the crop was $95.00 per ton. The average profit of $32.54 per ton for the period has returned a very satisfactory percentage on the investment in this vineyard. The returns in this instance indicate that the fairly uniform yields produced in four of the five years have contributed materially to the financial gain that this vineyard shows. However, if a charge were to be made for the time spent by the grower in superintending the work, the profit would be considerably less. Grower R has devoted quite a little time to this work without which it is probable that the high yields could not have been secured.

COMPARISON OF THE DIFFERENT VINEYARDS

A consideration of the data secured from the three vineyards may throw some light on the effect upon profits of the different methods of management. The vineyards are located in widely separated parts of the grape belt. However, two of them are situated on very similar soil types while a portion of the third is on much the same sort of soil. Probably two-thirds of the vineyards of the section are on soils similar to those of Vineyards E and R.

Vineyard E has been owned by the present occupant for many years, but Vineyards R and S have been under the present management for the past ten years only.

Vineyards E and R are so alike as to soil that they should be equally productive and if the same attention was given to each operation the cost in the one should not exceed that in the other. It is generally conceded that vineyards situated on the lighter

soils, such as Dunkirk gravelly loam, are worked more easily and cheaply than those on clay and clay loam soils.

MAINTENANCE

From Tables 2, 5, and 8 it will be seen that the average total maintenance per acre for Vineyard R exceeded that of vineyard E by $4.13, while that for Vineyard S was $14.23 more. The larger part of this increase was spent for fertilizers and green manure seed altho over $2.00 of it went for taxes and insurance. The proximity to town has made the tax rate for Vineyard S considerably higher than for Vineyard E. While Vineyards E and R have had very similar amounts invested in fertilizer and manure, the kinds and prices for the two have been quite different. Grower E spent a large part of his money for commercial phosphorus and stable manure, while Growers R and S invested largely in commercial nitrogen and phosphorus.

While it cost less per acre to maintain Vineyard E than Vineyards R and S, Tables 3, 6, and 9 show that the cost per ton in the former has been the greatest, amounting to $9.34 more than for Vineyard R and $3.36 more than for Vineyard S.

LABOR

Turning to the labor items, it is to be noted that Growers E and R have spent very similar amounts for pruning, while it has cost Grower S about 75 cents more per acre to prune his vines. Growers E and S have spent approximately like amounts for removing the brush from the wires and for its final disposal, while Grower R has spent on an average of $1.00 per acre more. Grower R has also invested considerably more in trellis repairs than either Growers E or S. The amount spent for spring tying was quite similar in Vineyards E and S, while this item cost about 75 cents per acre more in Vineyard R. Grower E invested on an average $7.03 per acre for tillage, Grower S $9.88, and Grower R $11.73. It will be noted that the average total labor expense per acre for the five years for Vineyard R is the highest, $26.72, as compared with $17.72 for Vineyard E and $21.77 for Vineyard S. However, each ton of grapes has cost Grower E $2.22 more for labor than it has Grower R and $3.69 more than Grower S.

UPKEEP

The total expense of upkeep for Vineyard E averaged $47.28 per acre, or $13.13 less than for Vineyard R, and $18.28 less than for Vineyard S. The increase in the case of Vineyard S was due largely to increased costs of maintenance, while the increase in Vineyard R was in maintenance and tillage.

From Tables 3, 6, and 9 it will be seen that the total average upkeep per ton of $38.96 in Vineyard E was $11.56 more than in Vineyard R and $7.05 more than for Vineyard S.

HARVESTING

Similar amounts have been spent in the three vineyards for harvesting as the average of the five years, the cost in Vineyard E being less per acre than in Vineyards R or S, altho the average tonnage handled has been considerably less in Vineyard E than in the others. Vineyards R and S, with approximately the same average yields, show a difference in the cost of handling of about 67 cents.

The cost of harvesting per ton varied but little in the three vineyards. Vineyards E and R differed by $1.27 per ton, while the cost of harvesting a ton in Vineyard S has been 87 cents less than in Vineyard R.

TOTAL COST OF PRODUCTION

The total cost of production in Vineyard E averaged $60.44 per acre, that for Vineyard R $78.74, and that for Vineyard S $83.22.

Tables 3, 6, and 9 show that it cost on an average $12.83 more to grow and harvest a ton of grapes in Vineyard E than in Vineyard R and $9.19 more than in Vineyard S. The higher tonnages secured in Vineyards R and S have been sufficient to overcome the differences in costs per acre.

NET RETURN

The net profit per acre from Vineyard E was $39.30 for the average of the five years, which was $34.58 less than that for Vineyard S, and $47.46 less than for Vineyard R. The net profit per acre in the latter case has been somewhat increased over the others due to a slightly higher selling price in some seasons.

Grower E netted $18.56 on each ton of grapes produced for the five years, or $9.29 per ton less than Grower S and $13.98 per ton less than Grower R.

The average cost per acre for growing and harvesting the crop from the three vineyards for the five years was $74.13, while the average cost per ton was $40.58. The average profit per acre from the three vineyards was $66.64 and the average profit per ton $26.31.

CONCLUSIONS

It is apparent from a study of the foregoing figures that Vineyards R and S have been more profitable than Vineyard E altho the latter has been operated at a smaller cost per acre than the others. The increased cost of production of Vineyards R and S have been overcome by higher yields. It is suggestive that perhaps the higher production is in part, at least, due to the manner of operating, not the least of which are the fertility and tillage phases. However, the fact should not be lost sight of that Vineyards R and S are relatively small acreages as compared with Vineyard E and hence the attention given them has been more exacting than is possible with more extensive plantings. Grower E had other farm activities, while Growers R and S were concerned exclusively with the production of grapes. In general the soil is more uniform over small areas than over large areas and undoubtedly soil irregularities render many vineyards unprofitable. Altho it is possible to increase the general productiveness of such vineyards, yet many spots must remain a liability from the very nature of the formation. The writer has noted as high as 25 per cent of the vines as missing or weak in some plantings as a consequence of unfavorable soil conditions.

While many vineyards are operated at costs equalling those of Vineyards R and S and return as large or even larger profits, most of the acreage in this region is maintained at less expense and returns a profit corresponding more nearly to that secured from Vineyard E. It is probable that the exact tonnage for the grape belt for the past five years falls below the average of 1.81 tons per acre for Vineyard E. As previously stated, Vineyards E and R are markedly superior to other vineyards in their locality and for their soil type.

The question naturally arises as to whether the vineyards of this region can be made as profitable as Vineyards R and S. When it is recalled that Vineyard R was typical of those of the neighborhood

a few years since, it would seem that this should be possible; but in view of the fact that many vineyards are situated on soils unsuited to grape growing, while many others include areas that can never be made profitable, the problem becomes more complicated.

While Vineyards E, R, and S have been improving or at least holding their own, the great majority of vineyards in this region have been slowly but surely declining, and it is only a question of a few years before they will of necessity be torn out. Vineyards on the better soil types and with a fair amount of root area no doubt can be made to produce larger and more uniform crops than they are producing at the present time.

The data herein presented suggest that under intensive management grape growing in the Chautauqua and Lake Erie fruit belt can be made profitable even with the high cost of labor and supplies if the selling price is maintained at or near the level of the past two seasons.

TABLE 1.— TOTAL COST OF PRODUCTION IN VINEYARD E, 1915-1919.

ITEMS	1915	1916	1917	1918	1919	5 YEAR AVERAGE
Interest on investment	$360.00	$360.00	$360.00	$360.00	$360.00	$360.00
Taxes and insurance	15.00	19.50	19.50	19.50	27.50	20.20
Fertilizer, manure, lime	39.86	94.23	123.00	213.40	161.00	126.30
Posts, wire, wire-ties, tools, staples, twine, etc	13.90	26.68	68.43	20.18	10.25	27.88
Green manure seed	....	16.05	33.00	114.00	31.20	38.85
Spray materials	25.68	19.50	24.00	....	15.50	16.94
Vines for replacement	2.10	....	3.65	....	....	1.15
Total maintenance expense	$456.54	$535.96	$631.58	$727.08	$605.45	$591.32
Pruning	$51.52	$70.50	$65.20	$81.00	$75.60	$68.76
Brush disposal, pulling, poling and burning	29.82	31.70	25.10	22.50	33.01	28.43
Trellis repair, driving posts, fixing braces and stretching wire	20.84	29.00	49.60	14.40	34.80	29.73
Tying	26.40	33.40	31.60	32.00	41.00	32.88
Plowing, single-horse	....	8.58	....	16.20	....	4.96
Plowing, team and tractor	50.20	35.13	19.50	40.80	53.20	39.77
Horse hoeing	10.68	28.53	....	42.75	....	16.30
Hand hoeing	11.00	14.30	1.40	43.20	....	13.98
Harrowing and discing	30.40	29.75	60.00	105.00	101.50	65.33
Spraying labor	10.20	17.50	17.00	....	45.50	18.04
Applying fertilizer	10.00	11.25	16.75	18.30	7.00	12.66
Green manure seeding	....	7.88	23.70	17.40	7.00	11.19
Miscellaneous, suckering, mowing weeds, etc	23.68	19.50	3.40	....	13.90	12.09
Total labor expense	$274.74	$337.02	$313.25	$433.55	$412.51	$354.21
Total upkeep expense	$731.28	$872.98	$944.83	$1,160.63	$1,017.96	$945.53
Harvesting, picking, horse and team work	$260.00	$342.38	$172.90	$198.40	$341.98	$263.15
Total cost production	$991.28	$1,215.36	$1,117.73	$1,359.03	$1,359.94	$1,208.68
Man hours till harvest	866.5	1,055.0	836.0	909.5	739.5	881.3
Woman hours till harvest	176.0	167.0	158.0	160.0	164.0	165.0
Horse hours till harvest	500.1	475.5	336.0	666.0	431.0	481.7
Tractor hours	....	30.5	76.0	32.0	54.5	38.6

TABLE 2.— COST OF PRODUCTION PER ACRE IN VINEYARD E, 1915–1919.

ITEMS	1915	1916	1917	1918	1919	5 YEAR AVERAGE
Interest on investment	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00
Taxes and insurance	.75	.97	.97	.97	1.38	1.01
Fertilizer, manure, lime	1.99	4.71	6.15	10.67	8.05	6.31
Posts, wire, wire-ties, tools, staples, twine, etc	.69	1.33	3.42	1.01	.51	1.39
Green manure seed	....	.80	1.65	5.70	1.56	1.94
Spray materials	1.28	.98	1.20	....	.78	.85
Vines for replacement	.10	....	.18	....	....	.06
Total maintenance expense	$22.81	$26.79	$31.57	$36.35	$30.28	$29.56
Pruning	$2.58	$3.53	$3.26	$4.05	$3.78	$3.44
Brush disposal, pulling, poling and burning	1.49	1.59	1.26	1.13	1.65	1.42
Trellis repair, driving posts, fixing braces and stretching wire	1.04	1.45	2.48	.72	1.74	1.49
Tying	1.32	1.67	1.58	1.60	2.05	1.64
Plowing, single horse	....	.43	....	.81	....	.25
Plowing, team and tractor	2.51	1.76	.98	2.04	2.66	1.99
Horse hoeing	.53	1.43	....	2.14	....	.82
Hand hoeing	.55	.72	.07	2.16	....	.70
Harrowing and discing	1.52	1.49	3.00	5.25	5.08	3.27
Spraying, labor	.51	.88	.85	....	2.28	.90
Applying fertilizer	.50	.56	.84	.92	.35	.63
Green manure seeding	....	.39	1.19	.87	.85	.56
Miscellaneous, suckering, mowing weeds, etc	1.18	.98	17	....	.70	.61
Total labor expense	$13.73	$16.88	$15.68	$21.69	$20.64	$17.72
Total upkeep expense	$36.54	$43.67	$47.25	$58.04	$50.92	$47.28
Harvesting, picking, horse and team work	$13.00	$17.12	$8.65	$9.92	$17.09	$13.16
Total cost production	$49.54	$60.79	$55.90	$67.96	$68.01	$60.44
Woman hours till harvest	8.8	8.35	7.9	8.0	8.5	8.31
Man hours till harvest	43.3	52.75	41.8	45.43	36.98	44.05
Horse hours	25.0	23.75	16.8	33.3	21.55	24.08
Tractor hours	....	1.52	3.8	1.6	2.72	1.93
Yield, tons per acre	3.04	2.5	1.26	.6	1.66	1.81
Selling price per ton	$29.50	$49.66	$42.00	$112.00	$99.25	$66.48
Net profit per acre	40.14	63.36	—2.98	—0.76	96.75	39.30

TABLE 3.— COST OF PRODUCTION PER TON IN VINEYARD E, 1915–1919.

ITEMS	1915	1916	1917	1918	1919	5 YEAR AVERAGE
Interest on investment	$5.921	$7.200	$14.285	$30.00	$10.843	$13.649
Taxes and insurance	.246	.388	.769	1.61	.831	.769
Fertilizer, manure, lime	.644	1.884	4.881	17.78	4.848	6.010
Posts, wire, wire ties, tools, staples, twine, etc	.220	.532	2.714	1.68	.807	1.090
Green manure seed	....	.320	1.309	9.50	.939	2.413
Spray materials	.421	.392	.952	....	.469	.446
Vines for replacement	.032	....	.142	....	....	.035
Total maintenance expense	$7.484	$10.716	$25.052	$60.57	$18.237	$24.412
Pruning	$0.848	$1.412	$2.580	$6.750	$2.280	$2.774
Brush disposal, pulling, poling and burning	.490	.636	1.000	1.880	.994	1.000
Trellis repair, driving posts, fixing braces and stretching wire	.342	.580	1.968	1.200	1.000	1.018
Tying	.434	.668	1.254	2.666	1.234	1.251
Plowing, single horse	....	.172	....	1.350	....	.304
Plowing, team and tractor	.792	.704	.777	8.400	1.602	1.455
Horse hoeing	.174	.572	....	3.560	....	.861
Hand hoeing	.180	.288	.055	3.600	....	.825
Harrowing and discing	.500	.596	2.380	8.750	3.600	3.165
Spraying, labor	.167	.352	.674	....	1.373	.513
Applying fertilizer	.164	.224	.666	1.533	.218	.561
Green manure seeding	....	.156	.944	1.450	.210	.552
Miscellaneous, suckering, mowing weeds, etc.	.388	.392	.134	....	.422	.267
Total labor expense	$4.479	$6.752	$12.432	$36.139	$12.933	$14.547
Total upkeep expense	$11.963	$17.468	$37.484	$96.709	$31.170	$38.959
Harvesting, picking, horse and team work	$4.275	$6.848	$6.865	$16.533	$10.295	$8.963
Total cost production	$16.238	$24.316	$44.349	$113.242	$41.465	$47.922
Yield, tons per acre	3.04	2.5	1.26	.6	1.66	1.81
Selling price per ton	$29.50	$49.66	$42.00	$112.00	$99.25	$66.48
Net profit per ton	13.262	25.344	—2.349	—1.242	57.785	18.560

TABLE 4.— TOTAL COST OF PRODUCTION IN VINEYARD S, 1915 TO 1919.

ITEMS	1915	1916	1917	1918	1919	5 YEAR AVERAGE
Interest on investment	$108.00	$108.00	$108.00	$108.00	$108.00	$108.00
Taxes and insurance	18.00	19.86	20.70	22.92	27.90	21.88
Fertilizer	67.86	88.56	88.44	107.04	114.96	93.37
Posts, wire, wire-tics, tools, staples, twine, etc	18.00	21.60	22.80	12.00	11.25	17.13
Green manure seed	15.12	3.46	13.50	18.00	24.42	14.90
Spray materials	9.30	6.00	6.00	16.02	....	7.45
Total maintenance expense	$236.28	$247.48	$259.44	$283.98	$286.53	$262.74
Pruning	$17.88	$15.42	$20.46	$36.00	$37.80	$25.51
Brush disposal, pulling, poling and burning	5.94	12.06	12.18	10.80	11.25	10.44
Trellis repair, driving posts, fixing braces and stretching wire	12.78	11.04	9.96	11.72	20.10	13.12
Tying, spring	3.90	6.84	7.38	11.88	12.67	8.53
Plowing, single horse	4.56	18.00	3.12	16.68	12.24	10.92
Plowing, team	6.48	6.42	4.98	6.78	7.80	6.49
Horse hoeing	8.04	8.64	7.44	13.98	6.54	8.93
Hand hoeing	6.72	6.06	5.52	8.28	10.16	7.35
Harrowing and discing	35.52	22.68	24.18	26.22	19.48	25.62
Clipping tops	.96	1.20	1.50	1.50	1.79	1.39
Summer tying	3.36	.60	.96	4.26	2.72	2.38
Spraying, labor	6.54	5.22	5.88	6.54	....	4.84
Green manuring, labor	2.10	1.26	6.36	3.84	3.30	3.37
Miscellaneous, suckering, mowing weeds, etc	....	8.46	....	....	....	1.69
Total labor expense	$114.78	$123.90	$109.92	$158.48	$145.85	$130.58
Total upkeep expense	$351.06	$371.38	$369.36	$442.46	$432.38	$393.33
Harvesting, labor, picking, horse and team work	$144.36	$63.90	$109.32	$50.46	$161.88	$105.96
Total cost production	$495.42	$435.28	$478.68	$492.92	$594.26	$499.31
Man hours till harvest	368.2	413.5	362.47	442.62	351.68	387.69
Woman hours till harvest	13.0	39.1	55.6	51.0	54.36	42.61
Horse hours till harvest	247.7	229.68	193.91	249.02	165.84	217.23

TABLE 5.— COST OF PRODUCTION PER ACRE IN VINEYARD S, 1915–1919.

ITEMS	1915	1916	1917	1918	1919	5 YEAR AVERAGE
Interest on investment	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00
Taxes and insurance	3.00	3.31	3.45	3.82	4.65	3.65
Fertilizer	11.31	14.76	14.74	17.84	19.16	15.56
Posts, wire, wire-ties, tools, staples, twine, etc	3.00	3.60	3.80	2.00	1.875	2.86
Green manure seed	2.52	.575	2.25	3.00	4.07	2.48
Spray materials	1.55	1.00	1.00	2.67	....	1.24
Total maintenance expense	$39.38	$41.245	$43.24	$47.33	$47.76	$43.79
Pruning	$2.98	$2.57	$3.41	$6.00	$6.30	$4.252
Brush disposal, pulling, poling and burning	.99	2.01	2.03	1.80	1.88	1.742
Trellis repair, driving posts, fixing braces and stretching wire	2.13	1.88	1.66	1.95	3.35	2.194
Tying, spring	.65	1.14	1.23	1.98	2.12	1.424
Plowing, single horse	.76	3.00	.52	2.78	2.04	1.820
Plowing, team	1.08	1.07	.83	1.13	1.30	1.082
Horse hoeing	1.34	1.44	1.24	2.33	1.09	1.488
Hand hoeing	1.12	1.01	.92	1.38	1.69	1.224
Harrowing and discing	5.92	3.78	4.03	4.37	3.25	4.270
Clipping tops	.16	.20	.25	.25	.298	.231
Summer tying	.56	.10	.16	.71	.453	.396
Spraying, labor	1.09	.87	.98	1.09	....	.806
Green manuring, labor	.35	.21	1.06	.64	.55	.562
Miscellaneous	....	1.41	....	....	....	.282
Total labor expense	$19.13	$20.69	$18.32	$26.41	$24.321	$21.774
Total upkeep expense	$58.51	$61.94	$61.56	$73.74	$72.08	$65.56
Harvesting, picking, horse and team work	$24.06	$10.65	$18.22	$8.41	$26.98	$17.66
Total cost production	$82.57	$72.59	$79.78	$82.15	$99.06	$83.22
Man hours till harvest	61.35	68.9	60.41	73.77	58.61	64.61
Woman hours till harvest	2.16	6.51	9.3	8.5	9.06	7.11
Horse hours till harvest	41.3	38.28	32.32	41.5	27.64	36.21
Yield, tons per acre	3.39	2.03	3.36	1.03	3.29	2.62
Selling price per ton	$30.00	$49.66	$42.00	$112.00	$99.25	$66.58
Net profit per acre	19.13	28.22	61.34	33.21	227.48	73.88

TABLE 6.— COST OF PRODUCTION PER TON IN VINEYARD S, 1915–1919.

ITEMS	1915	1916	1917	1918	1919	5 YEAR AVERAGE
Interest on investment	$5.310	$8.870	$5.350	$17.47	$5.47	$8.494
Taxes and insurance	.885	1.630	1.030	3.71	1.41	1.733
Fertilizer	3.330	7.270	4.390	17.32	5.82	7.626
Posts, wire, wire-ties, tools, staples, twine, etc	.885	1.773	1.130	1.94	.57	1.259
Green manure seed	.743	.283	.670	2.91	1.24	1.169
Spray materials	.448	.492	.297	2.59	....	.765
Total maintenance expense	$11.60	$20.32	$12.87	$45.94	$14.51	$21.05
Pruning	$0.879	$1.260	$1.020	$5.82	$1.945	$2.185
Brush disposal, pulling, poling and burning	.292	.990	.604	1.75	.570	.841
Trellis repair, driving posts, fixing braces and stretching wire	.625	.926	.494	1.89	1.018	.991
Tying, spring	.191	.561	.366	1.92	.644	.736
Plowing, single horse	.224	1.480	.155	2.70	.620	1.036
Plowing, team	.318	.527	.247	1.09	.395	.515
Horse hoeing	.395	.709	.369	2.26	.330	.813
Hand hoeing	.330	.497	.273	1.34	.513	.591
Harrowing and discing	1.740	1.869	1.200	4.24	.987	2.005
Clipping tops	.047	.009	.074	.24	.090	.112
Summer tying	.165	.049	.048	.69	.137	.217
Spraying, labor	.321	.428	.291	1.06	....	.420
Green manuring, labor	.103	.103	.315	.62	.167	.261
Miscellaneous	......	.694	....	....	....	.139
Total labor expense	$5.63	$10.18	$5.46	$25.62	$7.42	$10.86
Total upkeep expense	$17.23	$30.50	$18.33	$71.56	$21.93	$31.91
Harvesting, picking, horse and team work	$7.09	$5.25	$5.42	$8.16	$8.20	$6.82
Total cost production	$24.32	$35.75	$23.75	$79.72	$30.13	$38.73
Man hours till harvest	18.10	34.00	17.90	71.60	17.60	31.84
Woman hours till harvest	.63	3.21	2.77	8.25	2.75	3.52
Horse hours till harvest	12.20	18.80	9.60	40.30	8.40	17.86
Yield, tons per acre	3.39	2.03	3.86	1.03	3.29	2.62
Selling price per ton	$30.00	$49.66	$42.00	$112.00	$99.25	$66.58
Net profit per ton	5.68	13.91	18.25	32.28	69.12	27.85

TABLE 7.— TOTAL COST OF PRODUCTION IN VINEYARD R, 1915-1919.

ITEMS	1915	1916	1917	1918	1919	5 YEAR AVERAGE
Interest on investment	$144.00	$144.00	$144.00	$144.00	$144.00	$144.00
Taxes and insurance	22.23	30.41	36.88	42.02	47.41	35.79
Fertilizer, manure, lime	68.00	37.23	55.00	24.70	68.00	50.58
Posts, wire, wire-ties, twine, staples, tools, etc	34.96	1.17	13.15	31.41	17.81	19.70
Green manure seed	....	2.90	....	10.45	15.00	5.67
Spray materials	17.28	....	....	7.50	7.25	6.41
Vine replacements	6.99	4.75	4.75	6.75	14.00	7.45
Total maintenance expense	$293.46	$220.46	$253.78	$266.83	$313.47	$260.60
Pruning	$17.04	$28.50	$28.00	$31.50	$35.00	$28.01
Brush disposal, pulling, poling and burning	18.32	14.50	24.85	34.20	26.00	23.57
Trellis repair, driving posts, fixing braces and stretching wire	29.70	12.20	19.00	14.60	46.00	24.30
Tying, spring	11.60	13.80	10.80	21.60	29.63	17.48
Plowing, single horse	5.28	5.25	....	10.80	10.80	6.42
Plowing, team	8.00	7.50	6.50	12.00	12.00	9.20
Horse hoeing	5.25	11.20	9.45	13.60	24.00	12.71
Hand hoeing	17.60	4.80	13.00	7.80	43.20	17.28
Harrowing	30.50	52.00	34.00	80.80	44.00	48.27
Clipping tops	2.07	2.75	3.00	3.30	4.00	3.02
Summer tying	5.75	8.55	....	6.00	....	4.06
Spraying, labor	19.36	....	....	11.00	8.00	7.67
Green manuring, labor	....	2.00	....	1.50	2.00	1.10
Miscellaneous, suckering, mowing weeds, tucking up	30.00	6.00	11.50	6.00	....	10.70
Total labor expense	$200.47	$169.05	$160.10	$254.70	$284.63	$213.79
Total upkeep expense	$493.93	$389.51	$413.88	$521.53	$598.10	$483.39
Harvesting, labor, teaming, containers, and cartage	$110.95	$96.77	$170.90	$118.80	$235.78	$146.64
Total cost production	$604.88	$486.28	$584.78	$640.33	$833.88	$630.03

TABLE 8.— COST OF PRODUCTION PER ACRE IN VINEYARD R, 1915–1919.

ITEMS	1915	1916	1917	1918	1919	5 YEAR AVERAGE
Interest on investment	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00
Taxes and insurance	2.78	3.80	4.61	5.25	5.92	4.47
Fertilizer, manure, lime	8.50	4.65	6.87	3.08	8.50	6.31
Posts, wire, wire-ties, twine, staples, tools, etc	4.37	.14	1.64	3.92	2.23	2.46
Green manure seed	....	.36	....	1.31	1.87	.71
Spray materials	2.16	....	....	.94	.91	.80
Vine replacements	.87	.59	.59	.84	1.75	.93
Total maintenance expense	$36.68	$27.54	$31.71	$33.34	$39.18	$33.69
Pruning	$2.13	$3.56	$3.50	$3.94	$4.37	$3.50
Brush disposal, pulling, poling and burning	2.29	1.81	3.11	4.28	3.25	2.95
Trellis repair, driving posts, fixing braces and stretching wire	3.71	1.52	2.37	1.82	5.75	3.03
Tying, spring	1.45	1.72	1.35	2.70	3.70	2.18
Plowing, single horse	.66	.66	....	1.35	1.35	.80
Plowing, team	1.00	.94	.81	1.50	1.50	1.15
Horse hoeing	.66	1.40	1.18	1.70	3.00	1.59
Hand hoeing	2.20	.60	1.62	.97	5.40	2.16
Harrowing	3.81	6.50	4.25	10.10	5.50	6.03
Clipping tops	.26	.34	.37	.41	.50	.38
Summer tying	.72	1.07	....	.75	....	.51
Spraying, labor	2.42	....	....	1.37	1.00	.96
Green manuring, labor	....	.25	....	.19	.25	.14
Miscellaneous, suckering, mowing weeds, tucking up	3.75	.75	1.44	.75	....	1.34
Total labor expense	$25.06	$21.12	$20.00	$31.83	$35.57	$26.72
Total upkeep expense	$61.74	$48.66	$51.71	$65.17	$74.75	$60.41
Harvesting, labor, teaming, cartage, and containers	$13.87	$12.10	$21.36	$14.85	$29.47	$18.33
Total cost production	$75.61	$60.76	$73.07	$80.02	$104.22	$78.74
Yield, tons per acre	2.66	2.47	2.72	1.18	3.72	2.55
Selling price per ton	$38.50	$50.63	$42.08	$112.00	$95.00	$67.64
Net profit per acre	26.80	64.29	41.38	52.14	249.18	86.76

TABLE 9.— COST OF PRODUCTION PER TON IN VINEYARD R, 1915–1919.

ITEMS	1915	1916	1917	1918	1919	5 YEAR AVERAGE
Interest on investment	$6.77	$7.290	$6.62	$15.25	$4.840	$8.15
Taxes and insurance	1.05	1.540	1.69	4.45	1.590	2.06
Fertilizer, manure, lime	3.20	1.880	2.52	2.61	2.280	2.50
Posts, wire, wire-ties, twine, staples, tools, etc	1.64	.056	.60	3.32	.600	1.24
Green manure seed	....	.145	....	1.11	.500	.35
Spray materials	.81	....	....	.80	.244	.37
Vine replacements	.33	.240	.22	.71	.470	.39
Total maintenance expense	$13.80	$11.15	$11.65	$28.25	$10.52	$15.07
Pruning	$0.800	$1.440	$1.280	$3.340	$1.170	$1.606
Brush disposal, pulling, poling and burning	.860	.730	1.140	3.620	.870	1.444
Trellis repair, driving posts, fixing braces and stretching wire	1.390	.610	.870	1.540	1.540	1.190
Tying, spring	.550	.696	.496	2.280	.990	1.002
Plowing, single horse	.248	.220	....	1.140	.360	.393
Plowing, team	.370	.380	.300	1.270	.400	.544
Horse hoeing	.248	.566	.433	1.440	.806	.698
Hand hoeing	.827	.240	.595	.820	1.450	.786
Harrowing	1.430	2.630	1.560	8.560	1.470	3.130
Clipping tops	.105	.137	.136	.346	.134	.171
Summer tying	.270	.430	....	.635	....	.267
Spraying, labor	.910	....	....	1.160	.268	.467
Green manuring, labor	....	.100	....	.160	.070	.066
Miscellaneous, suckering, mowing weeds, tucking up	1.370	.300	.520	.630	....	.564
Total labor expense	$9.38	$8.48	$7.33	$26.94	$9.53	$12.33
Total upkeep expense	$23.18	$19.63	$18.98	$55.19	$20.05	$27.40
Harvesting, labor, teaming, cartage, and containers	$5.21	$4.90	$7.85	$12.58	$7.92	$7.69
Total cost production	$28.39	$24.53	$26.83	$67.77	$27.97	$35.09
Yield, tons per acre	2.66	2.47	2.72	1.18	3.72	2.55
Selling price per ton	$38.50	$50.63	$42.08	$112.00	$95.00	$67.64
Net profit per ton	10.11	26.10	15.25	44.23	67.03	32.54

ASEXUAL INHERITANCE IN THE VIOLET
(*Viola odorata*) *

ROY D. ANTHONY

SUMMARY

In the improvement of fruit varieties the question of fixity of type in asexual propagation is of very considerable importance. The use of any of the tree fruits in a study of this problem would obviously extend the experiment far past the activity of a single investigator. In order to hasten work on this question the double violet, Marie Louise, which is propagated asexually, was used in a study of the effect of selection upon the length of blossom stem. Observations were also made of the inheritance of high and low yield.

Four selection groups were made: long-stem plants of high yield, long-stem plants of low yield, short-stem plants of high yield, and short-stem plants of low yield.

The first year it was not realized how important a rôle plant vigor would play and so no record of this factor was made. Since then the plants have been graded for vigor twice each season.

One of the greatest difficulties encountered has been to find the best methods of showing the year's work and of making the selections for the following year. The method of selecting the plants for propagation was changed after two years.

Two sets of charts were used, one where the yield and stem-length of individual plants or of clonal groups are correlated with vigor and a second series showing the influence of location in the house upon yield, stem-length, and vigor. The length of all blossom stems is reported in one-half inch units and this unit is employed in the charts.

Correlation tables are given for the three factors for the entire house for each year of the experiment and for each of the four selection groups for the last year.

For purposes of comparison, the four selection groups were reduced to the same vigor by means of the regression coefficient.

Environmental factors caused considerable variation within the same greenhouse, especially the first year of the experiment.

The second year, the vigor and yield were approximately the same for the long-high and short-high groups but there was a lower stem-length average in the short-stem than in the long-stem selection.

* Reprint of Technical Bulletin No. 76, March, 1920. Also presented to the faculty of the Graduate School of Cornell University as a thesis in partial fulfillment of the requirements for the degree of doctor of philosophy.

This second year four plants were grown from every plant selected as a parent the first year. The record of these four plants showed that many of the first selections, based on the performance of one plant and without a knowledge of its vigor, were not correct.

The third year the two high-yielding selections gave a slightly higher yield than the low selections but the difference was less than twice the probable error. At the same time in the two high-yielding selections the difference in stem-length in favor of the long-stem group was about five times the probable error and in the low-yielding selections about nine times.

The fourth year there were supposed to be sixty-four plants from a common parent in 1914. In the long-stem selections, the high-yielding group averaged 3.108 ± 0.441 blossoms more than the low-yielding plants. In the short-stem selection the high-yielding plants averaged 5.787 ± 0.478 more than the low-yielding plants. In both the high-yielding and low-yielding selections the long-stem plants averaged, respectively, 0.361 ± 0.036 units and 0.495 ± 0.041 units longer than the short-stem plants.

The fifth year of the experiment, in the long-stem selections the high-yielding plants averaged 1.847 ± 0.754 blossoms more than the low-yielding plants. In the short-stem selections the high-yielding plants showed a gain of 4.970 ± 0.767 blossoms. The long-stem groups in both the high and low yielding selections gained 0.368 ± .046 and 0.346 ± .048 units, respectively.

The process of selection has really been one of isolation whereby certain clonal lines have been selected out of the miscellaneous population purchased in 1914. We seemingly have proved only the existence of asexually inherited differences which probably were present before the experiment was begun. No attempt has been made to find when or how such differences arose.

Tho the existence of such differences in the violet makes it seem more probable that there may be differences within a single variety of any fruit, the labor and the technical difficulties involved render it inadvisable for a nurseryman to attempt to find beneficial variations among fruits by bud selection.

INTRODUCTION

THE PROBLEM

All commercial fruits of America are propagated by asexual means. This fact creates a fundamental difference in the problem of the improvement of our present fruit varieties as compared with the improvement of most vegetables and field crops where reproduction is by sexual means.

The development of the idea of pedigree and all it involves has had such a profound influence upon the live-stock industry that it

is only natural for the fruit-grower to be influenced in his thought of his trees by this same idea. The growth of this trend of thought has been hastened by the exploitation of the term "pedigree" by a number of nurserymen who have sought by its use to convince the buyer that their trees were better than ordinary trees, tho the exact grounds upon which this statement was based seem frequently to be uncertain even in the minds of the nurserymen themselves.

Since 1896, the Geneva Station has been working on a problem in orchard fertilization where the question of the fixity of type in asexual propagation is of considerable importance. That year an orchard of Ben Davis trees was planted for a fertilizer experiment. The trees were then top-worked to Rome, the buds all coming from a single tree. In 1912 a problem in selection within a clonal line was started when buds were taken from the highest and from the lowest yielding trees in each fertilizer block and budded on own-rooted Spy stocks. These were planted on a uniform soil and are now nearly ready to begin fruiting.

At about the time this second test was started, an attempt was made to study the fixity of type in the Baldwin by planting an orchard of trees secured from every part of the country and showing as wide a diversity as possible in their "pedigree." It is too early yet to know what the value of this last experiment will be, but owing to the conditions surrounding the orchard it is doubtful if it can be relied upon to show conclusive results.

It is obvious that work of this sort with species as slow in coming to maturity as are the tree fruits, must, of necessity, run far past the span of the working life of a single investigator. Even with the bush and small fruits progress would still be slow and these fruits are very susceptible to environmental changes. Therefore, in order to hasten the work on this problem, it was decided, in the spring of 1914, to grow the double violet, Marie Louise, in the greenhouse and to study the effect of selection upon the length of stem of the blossoms. That fall eight hundred plants were purchased from a commercial grower and planted in the greenhouse.

The first question to be answered was whether from a mixed population types, or strains, could be isolated which would hold true to their selection year after year. The occurrence of "sports" in many horticultural crops is well known, altho when we consider the opportunities for their production the number that have been isolated and proved to reproduce themselves is almost negligible. Some recent investigations would seem to indicate that citrus is an exception and that this genus is in a state of change, producing new types frequently.

One variety of apple commonly grown in New York, the Twenty Ounce, has rather recently produced three sports, while a fourth can probably be credited to it. It is doubtful, however, if this number of sports has been found in all the other fruits grown in this State. Of course such sports represent sufficiently great changes to

be seen readily and to stand out from the minor fluctuations due to environment. Whether or not there are heritable differences too small to be detected in the commercial plantations is a question of fundamental importance to all engaged in the attempt to improve our fruits.

As the first five years' work with the violet seems to throw some light on this subject and as this year marks the beginning of the second phase of the problem, namely, whether by further selection isolated types may be shifted in either direction or even split into a multiplicity of types, it has seemed best to publish the data at this time.

LITERATURE

So many excellent discussions of the general subject of bud variation have appeared in the last few years that it would seem unnecessary to present a very extensive bibliographic review. However, attention should be called to certain of these publications.

The potato was the first asexually propagated plant in which improvement was generally sought by means of selection. A review of much of the early work with this plant is presented by Stuart (1915).[1]

The results of one of the most successful experiments in the selection of somatic variations were presented by Stout (1915). His work with Coleus did much to call the attention of investigators to this problem.

Dorsey (1916) has given us an excellent review of the literature bearing on several phases of the question of bud variation.

Jennings' work (1916) with Difflugia is very interesting as it involves a quite different type of reproduction. The chapter devoted to bud selection in Babcock and Clausen's book (1918) is a splendid critical study of the different phases of this problem.

The most recent contributions from the horticultural standpoint have been Shamel's articles (1918) dealing with citrus fruit improvement.

DESCRIPTION OF MATERIAL USED

The double violet, Marie Louise, for fifty years has been one of the most widely grown varieties in commercial and amateur houses. It is entirely sterile and is propagated by the separation of shoots from the original plant. So far as we have been able to find, the variety runs very uniform. While one or two so-called strains have been produced, the fact that they have never made their way into commercial culture would seem to indicate that they differed little if at all from the true variety. Altho the previous treatment of the 800 plants with which the experiment was started was not known, it is safe to assume that they would trace back to a very few parent

[1] Reference to Literature Cited, page 471.

plants in a few generations as nurserymen are constantly propagating from their best plants and each healthy plant yields eight or ten cuttings.

These plants were placed in the south house of a range of three running east from the main house. The south-east corner of the house is exposed to some of our coldest winds and fluctuations of several degrees in temperature have been noted between this corner and the sheltered north-west corner. The main house at the west not only shelters from the wind but also has a tendency to decrease the light received in the north-west quarter of the house. This point will be discussed somewhat in detail later. Within the house are two tile-bottom benches, each holding 400 plants in fifty rows of eight plants to the row. These two benches will be referred to as the north and south benches, respectively.

New plants are propagated each year either by allowing roots to form on the shoots, which are put out at the base of the crown, before the cuttings are taken, or the shoots are taken off just as the roots start to form. The shoots are then put in flats filled with sand. When root-growth is well started, the shoots are transferred to thumb pots and later, to larger pots and placed in cold frames for the summer. The plants are set in the benches about the first of September.

The first few blooms that form usually have very short stems and are imperfect and these are discarded without measuring. The first regular picking is made about the middle of October. With a slight jerk the stems separate readily from the plant and the entire length from the base of the blossom is measured in units of one-half inch.

As it was necessary to tabulate the results before plants could be selected for propagation for the following year, the last harvest record was usually made early in March, at a time when the plants were giving nearly maximum yields.

METHODS

House records.— Tho the experiment was to deal primarily with blossom-stem length, it was decided to study inheritance of high and low yield also as yield records had to be taken in getting stem-lengths. As plants were selected for long and short stem and high and low yield, this gave four selection groups: long-stem plants of high yield, long-stem plants of low yield, short-stem plants of high yield, and short-stem plants of low yield. In order to shorten the records and the discussion, these groups are usually referred to as follows: long-high, long-low, short-high, and short-low, respectively.

The records are taken in the greenhouse on large sheets 14 by 17 inches, cross-ruled into quarter-inch squares. The plant number is placed at the left and the date at the top. Each flower-stem is measured and the length to the nearest one-half inch placed in the

next square. When each harvest is over, a vertical line is drawn outside of the last record of the highest yielding plant. In this way the first records of the following harvest for all plants are in the same vertical line of squares, making it easy to study the yield fluctuation of any particular plant from harvest to harvest, and showing the relation of any plant to the maximum yield of that harvest.

With conditions at their best, the bed is picked over every week or ten days but in very cold weather it may be three weeks or more between harvests. When the large record sheets are filled they are totaled for each plant. In an average season, when the third series of sheets is filled, the records are discontinued and propagation commenced for the following year. For the first year the various factors were studied for each of these three harvest periods but since then only for the total harvest.

When the experiment was begun it was not realized how important a rôle plant vigor would play and so the first year no record was made of this factor but the need of it was clearly seen when it became necessary to select plants for propagation for the following year. There seemed to be no feasible way of weighing the plants or measuring their leaf surface and so the vigor was estimated in percentage, the most vigorous plants being graded as 100 and a few plants, with only a half dozen or so leaves and practically no blossoms, graded as 10. Two persons cooperated in this work, each checking the other, and it is doubtful if a third person would have shifted any of the plants more than ten points in the vigor score. The vigor was taken twice, once when the plants were coming into full bloom early in the winter, and a second time just before the selection of the plants for propagation for the next year. In computing final records the average of the two observations was used.

In a very general way, plants recorded as having a certain vigor were somewhat alike from year to year; but, because of the variations of the plants in different seasons, it is not possible to compare the vigor records of two different years with each other except in so far as each is considered as a statement of the relative values of the plants for that particular year.

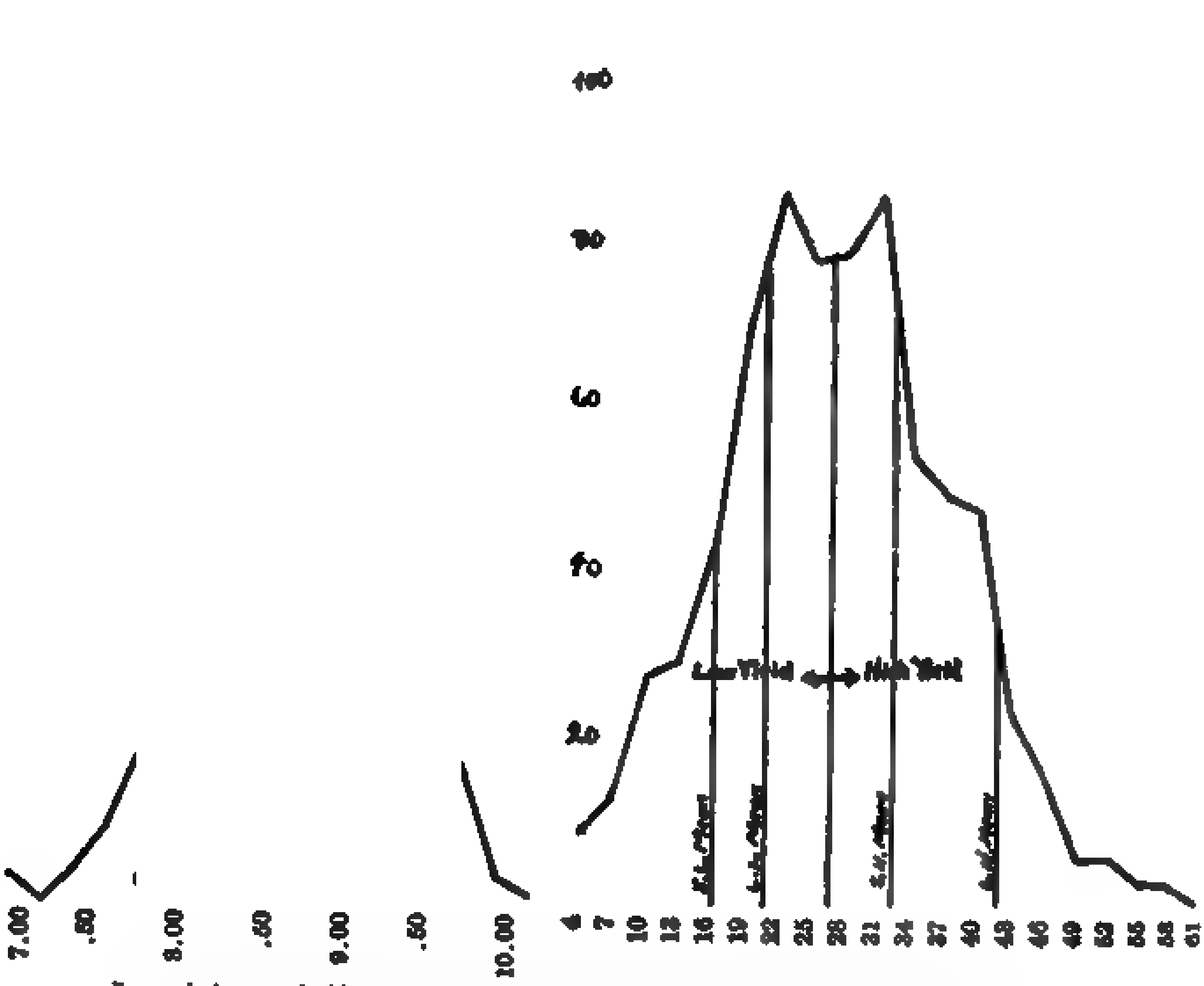
Statistical methods.— In order to simplify the problem of studying the plants and especially of making selections for the next year's propagation, the number, yield, and stem-length of each plant was placed on a single card and the cards grouped according to the line of selection. These cards could then be shuffled for any factor, and frequency charts and correlation tables very quickly prepared. This method has resulted in a considerable saving in time and has been a very important help in analyzing the data.

One of the greatest difficulties encountered in the experiment was to find the best method of showing the results of the year's work and of making the selections for the following year. The method of selecting the plants for propagation was not the same for the first

two years as is now used. In these early years the records were thrown into frequency tables and certain maximum or minimum yields and lengths selected until the number of plants which it was planned to propagate was isolated. This is well illustrated by Chart VIII which shows the selection standards for the first year in connection with the frequency curves of length and yield. The lines from which the arrows are drawn show the selection limits.

CHART VIII.— FREQUENCY CURVES OF LENGTH AND YIELD, 1914–15.

LENGTH. YIELD.



Length in one-half inches. Yield per plant.

By selecting the plants from the frequency curve and without knowledge of their vigor, any plants which were high-yielding because of abnormally high vigor were selected and the same was true with plants of low yield, due to lack of vigor. This objection has now been overcome by a somewhat different method of selection. Each plant or group of plants is plotted according to vigor on a chart with a common base line and with the yield plotted above and the stem-length below the vigor line. (See Chart XI.) In this way two

TABLE I.— STATISTICAL VALUES FOR THE ENTIRE HOUSE AND FOR THE SELECTION GROUPS FOR FIVE YEARS.

GROUPS.	STANDARD DEVIATION.			AVERAGE.			NUMBER OF PLANTS.
	Length.	Yield.	Vigor.	Length.	Yield.	Vigor.	
Total house 1914–15....	.510±.008	10.464±.183	....	8.836±.012	27.969±.259	....	742
Total house 1915–16....	.672±.017	10.970±.217	18.05±.357	8.600±.018	33.590±.306	49.99 ±.505	581
Group totals							
L. H. 1915–16..........	.674±.021	11.03±.345	15.59±.488	8.822±.029	32.44±.488	47.00± .690	232
L. L. 1915–16..........	.772±.030	11.24±.446	20.58±.818	8.515±.043	34.18±.631	51.25±1.156	144
S. H. 1915–16..........	.611±.028	9.97±.466	14.60±.683	8.369±.040	31.77±.659	49.19± .963	104
S. L. 1915–16..........	.648±.030	10.29±.488	20.78±.986	8.683±.043	36.24±.691	55.44±1.396	101
Total house 1916–17....	.602±.011	11.50±.217	17.65±.333	8.489±.016	31.74±.306	53.17± .471	639
Group totals							
L. H. 1916–17..........	.592±.020	11.04±.380	17.47±.601	8.546±.028	30.08±.537	49.34± .850	192
L. L. 1916–17..........	.579±.023	10.51±.431	17.47±.712	8.664±.033	31.73±.605	56.09±1.007	137
S. H. 1916–17..........	.665±.024	11.93±.435	17.69±.645	8.511±.033	34.56±.603	56.43± .895	171
S. L. 1916–17..........	.498±.020	11.74±.475	16.45±.665	8.213±.028	30.61±.672	51.65± .941	139
Total house 1917–18....	.585±.010	6.83±.124	22.01±.401	7.535±.015	16.36±.176	52.59± .567	683
Group totals							
L. H. 1917–18..........	.394±.016	5.44±.220	20.55± .834	7.749±.026	17.54±.312	51.88±1.180	138
L. L. 1917–18..........	.643±.023	5.94±.220	27.49±1.020	7.804±.033	14.52±.311	52.12±1.443	165
S. H. 1917–18..........	.475±.017	7.46±.277	20.31± .756	7.461±.025	20.69±.393	57.19±1.070	164
S. L. 1917–18..........	.525±.017	5.92±.192	19.86± .644	7.278±.024	13.73±.271	49.90± .911	216
Total house 1918–19....	.650±.011	10.92±.197	13.31± .240	8.331±.016	36.36±.278	81.44± .339	699
Group totals							
L. H. 1918–19..........	.574±.021	9.63±.357	13.72± .509	8.353±.030	35.56±.505	79.24± .720	165
L. L. 1918–19..........	.618±.022	11.09±.404	14.56± .531	8.557±.031	35.28±.572	82.60± .751	171
S. H. 1918–19..........	.712±.025	11.06±.402	12.22± .444	8.088±.036	41.06±.569	82.67± .628	172
S. L. 1918–19..........	.661±.022	10.72±.370	12.79± .441	8.173±.031	35.26±.515	81.20± .614	191

TABLE I.—STATISTICAL VALUES FOR THE ENTIRE HOUSE AND FOR THE SELECTION GROUPS FOR FIVE YEARS (*concluded*).

Groups.	Coefficient of correlation.			Regression coefficient.			Computed mean values.		
	Vigor and length.	Vigor and yield.	Length and yield.	Length to vigor.	Yield to vigor.	Length to yield.	Length.	Yield.	Vigor.
Total house 1914-15	....	....	.415±.019	......	......	.020	8.836±.012	27.969±.259	....
Total house 1915-16	.807±.009	.739±.012	.729±.012	.030	.449	.044	....	....	....
Group totals									
L. H. 1915-16	.779±.017	.775±.017	.727±.021	.033	.488	.044	8.920±.029	34.080±.488	49.996±.505
L. L. 1915-16	.706±.028	.771±.022	.609±.028	.026	.421	.047	8.483±.043	33.650±.631	49.996±.505
S. H. 1915-16	.724±.031	.741±.029	.524±.047	.030	.509	.032	8.393±.040	32.180±.659	49.996±.505
S. L. 1915-16	.895±.013	.699±.034	.678±.036	.027	.346	.042	8.537±.043	34.360±.691	49.996±.505
Total house 1916-17	.611±.016	.793±.009	.716±.012	.020	.517	.037	....	....	....
Group totals									
L. H. 1916-17	.694±.024	.749±.021	.623±.029	.023	.473	.033	8.635±.028	31.893±.537	53.177±.471
L. L. 1916-17	.640±.033	.728±.026	.692±.029	.021	.438	.038	8.603±.033	30.460±.605	53.177±.471
S. H. 1916-17	.613±.031	.786±.019	.638±.030	.023	.530	.035	8.437±.034	32.837±.603	53.177±.471
S. L. 1916-17	.669±.031	.752±.024	.621±.035	.020	.537	.026	8.243±.028	31.436±.672	53.177±.471
Total house 1917-18	.600±.016	.550±.017	.387±.021	.015	.171	.033	....	....	....
Group totals									
L. H. 1917-18	.723±.027	.445±.045	.548±.039	.013	.117	.039	7.758±.026	17.695±.312	52.591±.567
L. L. 1917-18	.764±.021	.636±.030	.647±.030	.012	.137	.070	7.812±.033	14.587±.311	52.591±.567
S. H. 1917-18	.590±.033	.515±.038	.262±.048	.013	.172	.016	7.397±.025	19.903±.393	52.591±.567
S. L. 1917-18	.555±.031	.475±.034	.391±.038	.014	.141	.036	7.317±.024	14.116±.271	52.591±.567
Total house 1918-19	.554±.017	.628±.012	.379±.021	.027	.746	.022	....	....	....
Group totals									
L. H. 1918-19	.645±.030	.655±.030	.461±.040	.026	.419	.028	8.409±.030	36.484±.505	81.447±.339
L. L. 1918-19	.655±.029	.733±.023	.515±.037	.027	.558	.028	8.525±.031	34.637±.572	81.447±.339
S. H. 1918-19	.660±.028	.642±.029	.536±.036	.038	.581	.034	8.041±.036	40.359±.569	81.447±.339
S. L. 1918-19	.480±.036	.592±.031	.377±.041	.024	.496	.023	8.179±.032	35.389±.515	81.447±.339

points are located for a single plant or group of plants, the one directly above the other, and the line connecting them passes thru the vigor value of the plant. As an aid in selection, a straight line was drawn thru each population in such a way as to divide the members in the various vigor classes into nearly equal parts. Inasmuch as the individuals near this line, the average plants, were discarded whenever possible, this method of dividing the population was deemed sufficiently accurate. To check this point, however, in several cases the straight line was determined by the formula, $y=mx+n$. The two lines were found to differ but little. Values lying above the line would then represent high-yielding or long-stem plants and those below the line low-yielding or short-stem plants.

By selecting from this chart it was possible to find those plants which were above or below the average at any particular vigor. This method has been used the last two years with very satisfactory results. In 1915–16 the selections were made on the basis of the average performance of the four plants tracing from a common origin the previous year. The following year the average of the sixteen plants with common origin was used and so on for each year, the total number tracing from a single plant in 1914 increasing by multiples of four each year.

A second series of charts (Chart X) is used to show the influence of location in the house upon the three factors studied and the relative fluctuation of those factors. These charts are also useful in showing the sudden jumps that frequently occur in passing from one type of selection to another when the plants lie in adjacent rows.

Correlation tables are made for the three factors for the entire house and for each of the four selection groups, and for each of these the following values are computed: Coefficient of correlation of vigor and length, vigor and yield, and length and yield; the standard deviation of length, yield, and vigor; the mean values of length, yield, and vigor; regression coefficients; and the corrected means where yield and length have been reduced to a common vigor by the regression coefficients.

These values are summarized in Table I and in the appendix are placed the correlation tables for the entire house for each year of the experiment and the correlations for each selection group for the last year. To include all the correlation tables seemed unnecessary since those which were selected show the general trend of the correlations.

A study of the correlation tables themselves without reference to computed values is of considerable help as it shows roughly the degree of correlation, the approximate averages, and the presence of any abnormal plants which need further study. If any sporting occurs in the factors studied it can be quickly detected by this means.

In studying the 1915–16 records a number of the correlations were worked out for the first and for the third periods of harvest.

The correlation between vigor and yield in the first group of pickings was low but for the third group considerably higher except for the short-low group and in the total this correlation is still higher with all groups. A study of the formula for correlation, $r_{yv}=\frac{\Sigma d_y d_v}{n\sigma_y\sigma_v}$, shows the mathematical reason for this. The total yields for the third group were of course considerably higher than for the first group of pickings and the total for the three groups very much higher. Thus, we have a constantly increasing Σdd in the numerator, while in the denominator the standard deviation for vigor does not fluctuate materially and the standard deviation for yield does not increase as rapidly as the summation so that we have a constantly increasing value for the coefficient of correlation. The fundamental reason is probably that by the third period of harvest the plants have reached their maximum production and under such conditions probably show greater correlation than earlier in the season. This variation in the correlation is another reason why it is difficult to compare different years with each other.

In Table II are summarized for the last four years the corrected mean yield and mean stem-length for the house and the differences for the contrasted selection groups. Such a summary is very convenient in the analysis of the data.

TABLE II.—FOUR YEAR SUMMARIES OF YIELDS AND STEM-LENGTHS.

Yield and length for each selection group computed for each year to average vigor of house.

YIELDS.			STEM-LENGTHS.		
Group yields.	Long stem.	Short stem.	Group lengths.	High yield.	Low yield.
1915–16					
High yield....	34.08 ±.488	32.18± .659	Long stem..	8.920±.029	8.483±.043
Low yield.....	33.65 ±.631	34.36± .691	Short stem..	8.537±.040	8.537±.043
Gain or loss.	.43 ±.797	—2.18± .954		.383±.049	—.054±.060
1916–17					
High yield....	31.893±.537	32.837±.603	Long stem..	8.635±.028	8.603±.033
Low yield.....	30.460±.605	31.436±.672	Short stem..	8.437±.034	8.243±.028
Gain.......	1.433±.808	1.401±.902		.198±.044	.360±.044
1917–18					
High yield....	17.695±.312	19.903±.393	Long stem..	7.758±.026	7.812±.033
Low yield.....	14.587±.311	14.116±.271	Short stem..	7.397±.025	7.317±.024
Gain.......	3.108±.441	5.787±.478		.361±.036	.495±.041
1918–19					
High yield....	36.484±.505	40.359±.569	Long stem..	8.409±.030	8.525±.031
Low yield.....	34.637±.572	35.389±.515	Short stem..	8.041±.036	8.179±.032
Gain.......	1.847±.754	4.970±.767		.368±.046	.346±.048

More should be said of the use of the regression coefficient. A study of the coefficients of correlation shows the high degree of correlation between vigor and yield and vigor and stem-length. For this reason it became necessary to find some way of reducing the various groups to a common vigor in order to compare yield and stem-length. This can be done with sufficient accuracy by means of the regression coefficient.[1] The four selection groups were reduced to the same vigor as the house average by multiplying the difference between the group average vigor and the house average vigor by the regression coefficient. If the group vigor was less than the house average this value was added to the group average length; if the group vigor was greater than the house average, it was subtracted from the group length.

INFLUENCE OF LOCATION IN HOUSE UPON YIELD AND STEM-LENGTH

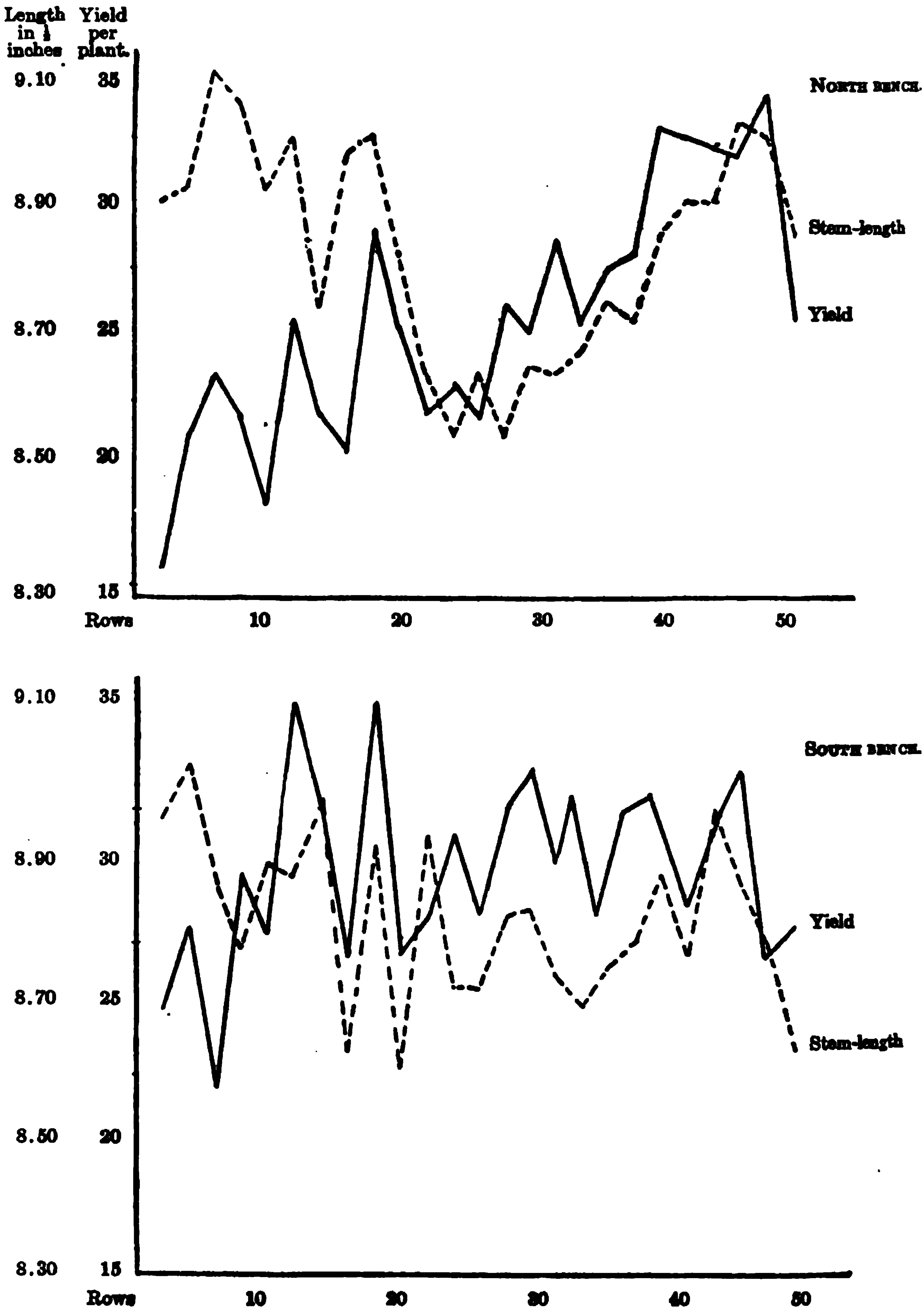
On first thought, one would expect that the house conditions were sufficiently uniform so that environmental variations could be excluded but a study of the year's record shows this not to be the case. Even after five years' study all of the factors causing variation can not be stated positively but the two most influential are probably temperature and light. As both of these differ in different seasons we find, in studying the house from year to year, indications of yearly variations so that any conclusions drawn from the first year's record must be applied to any other year only with many reservations.

Chart IX shows the yield and average stem-length for 1914–15 for groups of sixteen plants in two adjacent rows as they stood in the two benches. Care was taken to have the soil and cultural treatment as uniform as possible and so it seems safe to say that any fluctuations of the groups are due to the influence of location in the house upon plant growth. In other years variations may be due to the selection as well as to the influence of position.

On the chart we notice a fluctuation in the north bench which has appeared to a greater or less extent in every year and has been an important factor in complicating the results in this bench. In the west half of the bench (the left side of the chart), the yield shows a peak extending about one-third of the way down the bench and there is a remarkable rise in the stem-length of this area. Year after year in this part of the bench have been the most vigorous plants, those with the longest stems, and, usually, those with the highest yield in the entire house. The eastern half of the bench this first year shows a constantly increasing yield and stem-length. This increase does not seem to be as pronounced in other years and just why it should show to the extent that it does this first year is

[1] The formula used was: Regression coefficient of length to vigor $= r_{LV} \frac{\sigma_L}{\sigma_V}$.

CHART IX.— INFLUENCE OF LOCATION IN HOUSE UPON YIELD AND STEM-LENGTH, 1914-15.



not known. In the south bench there are some rather sharp fluctuations in stem-length and, in general, the yield fluctuates with the length. Taking the whole of the south bench into consideration no marked change seems to show which could be laid to environment. In the light of the other years' records, however, the tendency of the stem-length to increase slightly at the west end while the yield decreases slightly is significant, and it is probably safe to say that the western half of the bench is somewhat more favorably located for stem-length development than the eastern half.

GENERAL DISCUSSION OF RESULTS FOR 1914–15

The first year no record was taken of vigor, only the total yield of each plant and the stem-length of each blossom being recorded. Altho the lack of a record of vigor decreases the value of the first year's results to some extent, our knowledge of the general relations of stem-length and yield gathered from the other four years enables us to interpret the results for the first year with considerable accuracy.

House values.— Because of the lack of the vigor record, it was possible to correlate only length and yield. The coefficient of correlation for the entire house was 0.415 ± .019, very considerably lower than the following year when it was 0.729 ± .012. This low correlation is due to the failure of the two factors to respond in the same degree to the house conditions affecting the west end of the two benches. This condition seems more noticeable this year than in the following years. The average length for the house was high, 8.836 ± .012 units, in proportion to the yield of 27.969 ± .259 blooms, as shown in Table III.

TABLE III.— FIVE YEAR SUMMARIES.

Mean values for entire house.

YEAR.	YIELD.	LENGTH.	VIGOR.
1914–15	27.969±.259	8.836±.012	....
1915–16	35.590±.306	8.600±.018	49.996±.505
1916–17	31.747±.306	8.489±.016	53.177±.471
1917–18	16.368±.176	7.535±.015	53.591±.567
1918–19	36.367±.278	8.330±.016	81.447±.339

It is probable that the commercial grower from whom these plants were purchased had been selecting for high vigor for years, and thus had been unconsciously selecting for long stems and high yield.

Selection of plants for 1915–16.— The method used in selecting the plants for propagation during the first years has already been described. Because of the errors involved in this method and because

of lack of knowledge of the vigor of the plants, many were marked for propagation along the four lines of selection which, in the light of our present knowledge, should have been discarded or should have been included in a different class from the one in which they were placed.

GENERAL DISCUSSION OF RESULTS FOR 1915–16

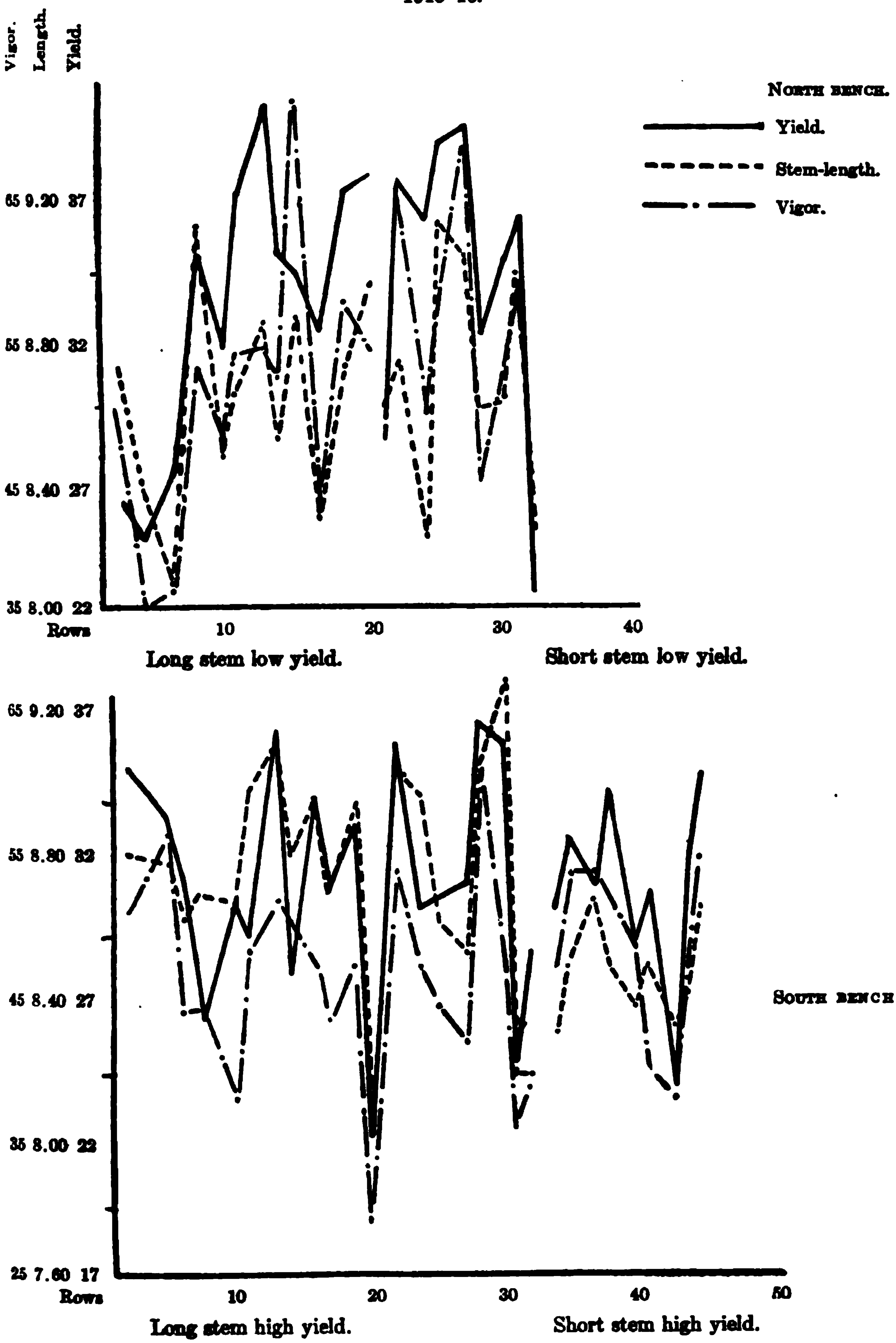
Before it was realized to what extent the factors under observation would be influenced by house conditions, the plants for the 1915–16 crop were planted in the house. The long-high and short-high groups were placed in the south bench and the long-low and short-low groups in the north bench. As the total number of plants this year was kept to about 700, all the groups save the long-high occupied somewhat less than a quarter of a bench.

House values.— From Chart X, where each point represents the average for twelve adjacent plants, it will be seen that, on the south bench, the vigor and yield were approximately the same for the two groups but that the line of stem-length is somewhat lower in the short-stem selection than in the long-stem selection.

On the north bench the region of high yield discussed under the previous year's data does not begin until the seventh or eighth row but seems to carry to the east to about the thirty-second row, covering practically the entire bench so far as it is occupied by these two groups. In this bench the fluctuations in vigor make it impossible to observe any certain differences in stem-length or yield in the two selections. Referring to Table II, where the summaries for the four years are given, we note that the average stem-lengths for these two groups do not show a significant difference while the stem-length difference in the south bench is $.383 \pm .049$ units in favor of the long-stem selection. Owing to the differences between the two benches it is difficult to draw any conclusion with regard to yield. On the west ends of the two benches the high-yield is slightly better than the low-yield selection when reduced to a common vigor. Most of the short-low plants on the north bench lie in a more favorable position than the short-high plants on the south bench and this probably accounts for this group being the higher yielding one contrary to the selection.

Selection of plants for 1916–17.— Each half row in the year 1915–16 originated from a single plant of the previous year. At the time that that single plant was selected to act as a parent only the one year's record was available to use in judging in which group the plant should fall. At the end of 1915–16 the record of the four plants with a common parentage showed clearly that a number of groups did not belong in the classes in which they had been placed. Some indeed were so far out of the class in which they were first placed that it seemed wise to select them for continued propagation in one

CHART X.—INFLUENCE OF LOCATION IN THE HOUSE ON YIELD, STEM-LENGTH, AND VIGOR, 1915–16.



of the other groups in which they now appeared to fall. Others of these abnormal plants were discarded. As all these plants were included in the group tabulations they have served to smooth out the results to some extent and hide any effects due to the selection.

Chart XI shows the distribution of the groups of four plants. The groups selected for further propagation are marked with the arrow, the direction of the arrow indicating the direction of the selection. The method illustrated in this chart was not developed until later and an inspection of the chart shows that some groups were retained which should have been discarded while many were discarded which should have been retained.

GENERAL DISCUSSION OF RESULTS FOR 1916–17

This year there were sixteen plants tracing back to a single plant placed in the house in 1914. These sixteen plants were set out in two rows of eight each, extending across the bench. Groups representing the same type of selection were scattered thru the house in such a way that the influence of house variations was probably very largely done away with so far as the summaries are concerned.

From an inspection of the graphs of the values for length, yield, and vigor, plotted for position in the house as shown in Chart XII, it would seem that there was somewhat less fluctuation on the north bench than was the case the first two years, especially in regard to yield and stem-length. There was, however, a tendency for the first sixteen rows from the west to be somewhat better than the next sixteen. In the previous year the high area on the north bench seemed to extend from about Row 10 thru Row 31. There was considerably more vaiation in the south bench than in the previous two years, there being an especially high area between Rows 8 and 18. The different selection classes were so scattered thru the house that no one class seems to have been affected by these areas more than the others.

House values.— Toward the latter part of the season, nematodes were found on the roots of several plants. These decreased the vigor and the yield of blossoms on a number of plants but in spite of this the house average yield was 31.747 ± .306 from November 3, 1916, to March 5, 1917. (See Table III.) The average stem-length for the same period was 8.489 ± .016 units, or 4.244 inches. It is probable that, because of the nematodes, our vigor standard was slightly lower than in the previous year as the average length of practically 8.5 units was from plants with an average vigor of 53.177 ± .471, while in 1915–16 the average length of 8.600 ± .018 was from plants with an average vigor of practically 50.

Group yields.— In the two groups selected for long stems, the high-yielding selection gave 1.433 ± .808 blooms more than the low selection and in the two short-stem groups the difference between the

Chart XI.—R

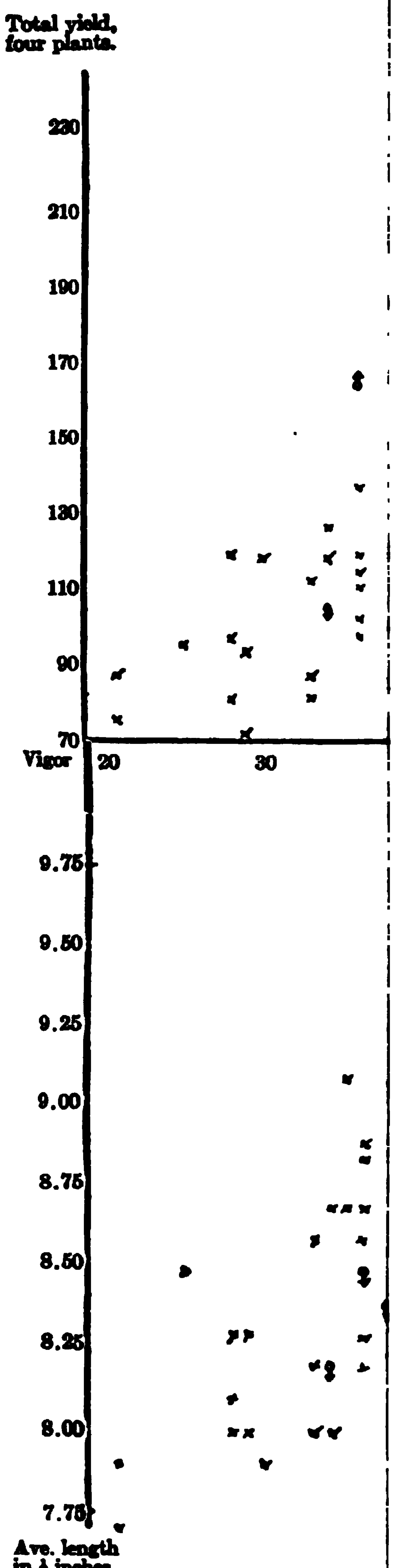
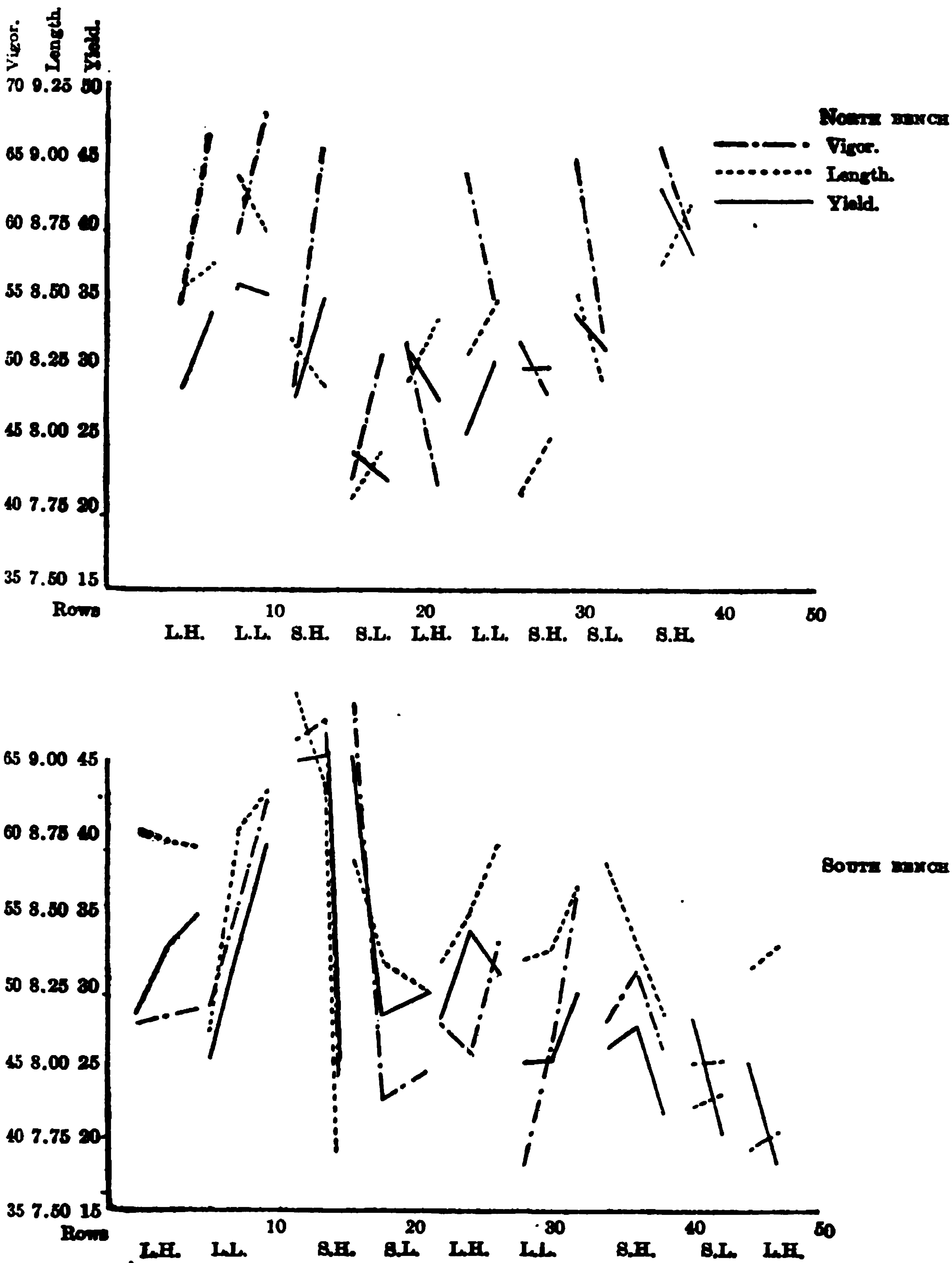

Total yield, four plants.
230
210
190
170
150
130
110
90
70
Vigor
20
30
9.75
9.50
9.25
9.00
8.75
8.50
8.25
8.00
7.75
Ave. length in ½ inches.

CHART XII.— INFLUENCE OF LOCATION IN HOUSE ON YIELD, STEM-LENGTH, AND VIGOR, 1916–17.



high and low selection was 1.401 ± .902 blooms. (See Table II.) This is not a large difference and in each case it is less than twice the probable error of the difference.[1]

Group lengths.— In the two high-yielding selections the average stem-length of the short-stem group was .198 ± .044 units below the average for the long-stem group and in the two low-yielding selections the average stem-length of the short-stem group was .360 ± .044 units below the long-stem group. (See Table II.) In the high-yielding group this difference is about five times the probable error and in the low-yielding group about nine times the probable error. It must be borne in mind that the selection, which is really a process of isolation, is not acting rapidly enough at the end of the first two selection periods for us to expect any very great difference. Such differences as these were, therefore, a surprise to all engaged in the work and may be considered as very significant in throwing light upon the trend of the experiment.

Selection of plants for 1917–18.— In making the selection for the following year, groups tracing back to a common parent plant in 1914 were treated as units. Chart XIII shows the distribution of the average values for these groups and those selected for further propagation.

GENERAL DISCUSSION OF RESULTS FOR 1917–18

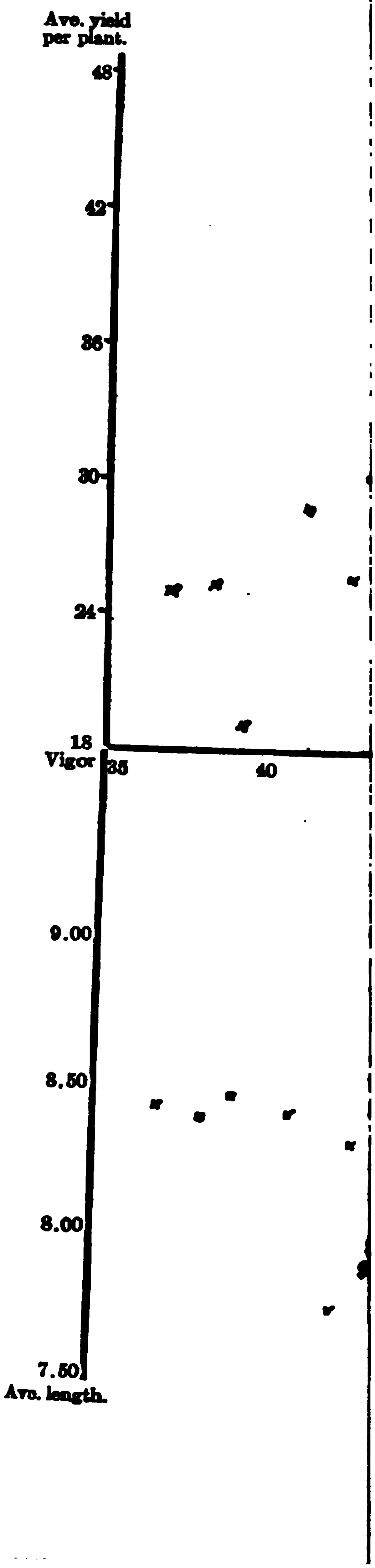
It was planned for this year that there should be sixteen rows of four plants each, all tracing back to a single plant in the 1914–15 population. It was not possible in all cases, however, to continue propagating at the rate of four to one and so some of the groups fall below a total of sixty-four. Plants having a common origin were not separated, but those groups which had a common selection were scattered through the house in order to eliminate, so far as possible, the influence of house variations. It would have been somewhat better had the units of sixty-four plants been split up into two or four groups and placed in different parts of the house.

House values.— The very unusual cold, together with the age and poor condition of the house, resulted in a very light yield. The average yield for the house for a period extending from November 20, 1917, to March 12, 1918, was 16.368 ± .176 blossoms. The average stem-length was 7.535 ± .015. But one vigor record was taken this year, that at the end of the picking season. The average vigor was 53.591 ± .567. (See Table III.)

Group yields.— In the long-stem selections the high-yielding group averaged 3.108 ± .441 blossoms more than the low-yielding plants. In the short-stem selection the high-yielding plants averaged 5.787 ± .478 more than the low-yielding plants. (See Table II.)

[1] The probable error of the difference is found by extracting the square root of the sum of the squares of the probable errors of the means which are compared.

Chart XIII


Ave. yield per plant.
48
42
36
30
24
18
Vigor
35
40
9.00
8.50
8.00
7.50
Ave. length.

Group lengths.— In the high-yielding selection the long-stem plants averaged .361 ± .036 units longer than the short-stem plants, and in the low-yielding selection the long-stem plants were, on the average, .495 ± .041 units longer. In comparison with the probable errors these differences are sufficiently large to remove any doubt of their value. (See Table II.)

Selecting plants for 1918–19.— The general correlations of the three factors are shown graphically in Chart XIV. Here, also, are indicated the plants retained for the next year.

This chart shows even more clearly than the figures given above that our process of isolation has separated out distinct groups. Thus, in the north-west quarter of the house, the long-low group and the short-high group have the positions of the stem-length and yield lines reversed at nearly the same vigor. The yield line of the long-high group is much higher at lower vigors than in the short-low group. On the west end of the south bench, the two contrasted selections, long-low and short-high, show a complete reversal in the relative positions of the yield and length lines.

In Chart XV the average yield and average stem-length of groups of twelve adjacent plants are plotted to the average vigor. Since there were as high as sixty plants in a single line, the points on the chart do not now represent the entire performance of a particular selection as has previously been the case in this type of chart.

GENERAL DISCUSSION OF RESULTS FOR 1918–19

Propagating the selected plants at the rate of four to one, there should be 256 tracing back to a common origin in 1914. Owing to the vicissitudes of propagation, however, this number was not retained in every case. In one or two cases the number was very considerably cut down, but in such cases this was done largely because of lack of room or the uncertainty as to whether that particular line would be continued further. The larger populations were broken into three groups and placed in different parts of the house. In this way it is probable that whatever house fluctuations there were have not seriously influenced the final average results. In general, the house fluctuations this year were not extreme. In Chart XVI, the usual peak is seen on the north bench but it is not extreme and seems to affect yield more than the other factors. The south bench shows many minor fluctuations but, on the average, it is fairly uniform.

House values.— The total yield per plant from October 18, 1918, to January 31, 1919, was 36.367 ± .278. The average stem-length was 8.33 ± .016. (See Table III.) The first two harvests of the season were very heavy and, as is always the case with the first harvest, there was a high proportion of short-stem blossoms. In other years the first harvest has been discarded because of these

CHART XIV.— INFLUENCE OF LOCATION IN HOUSE ON YIELD, STEM-LENGTH, AND VIGOR, 1917–18.

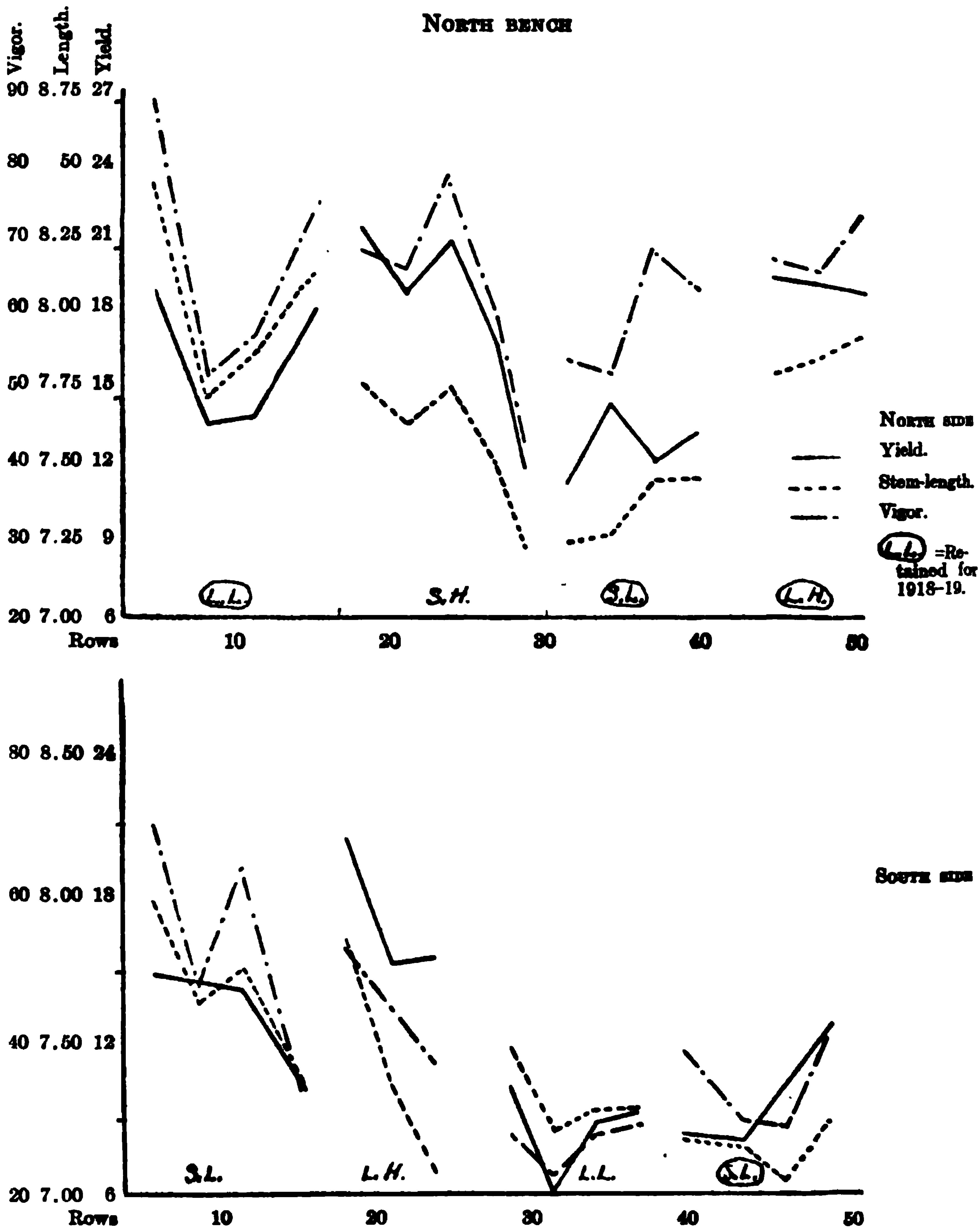
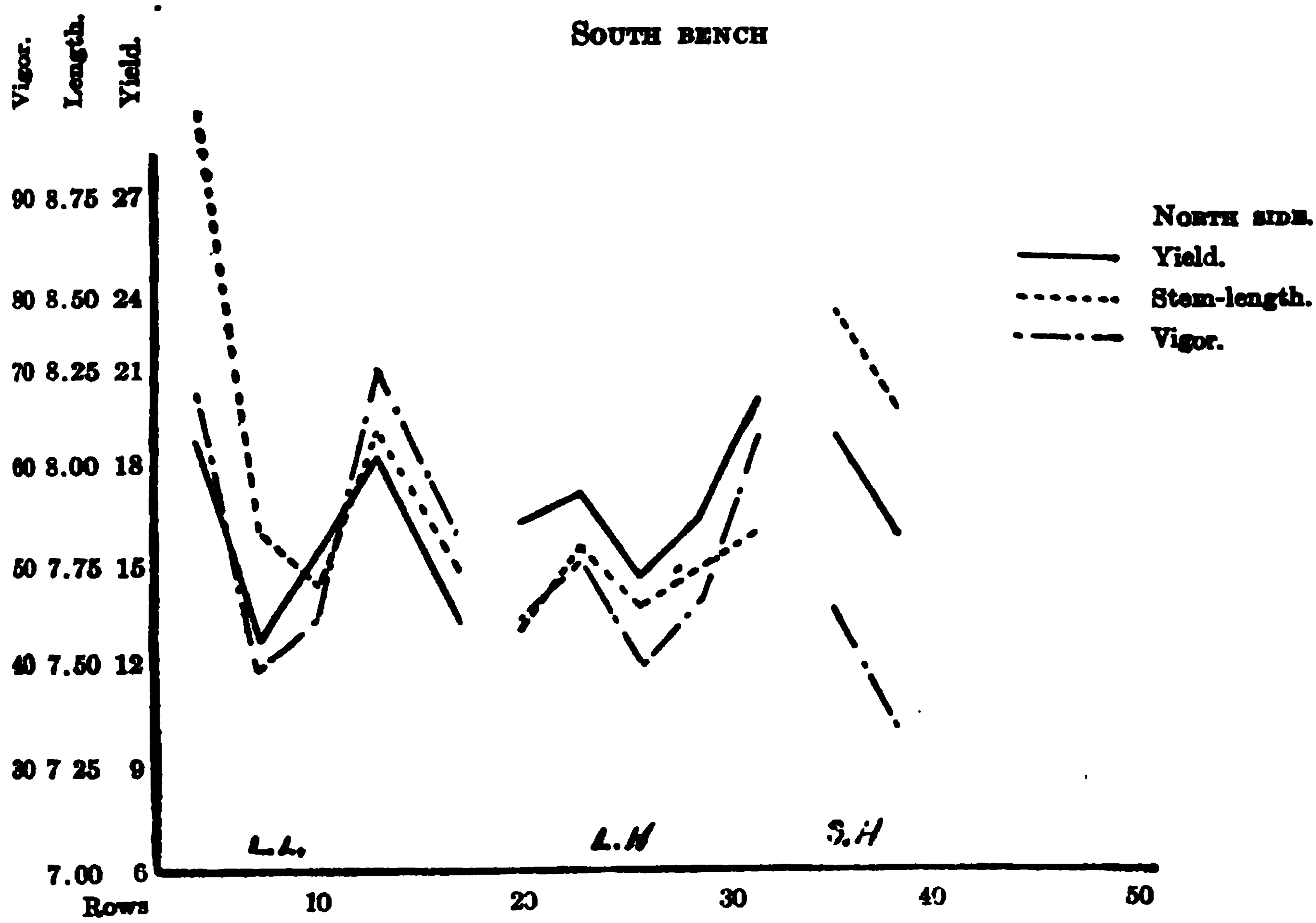


CHART XIV (*continued*).

SOUTH BENCH



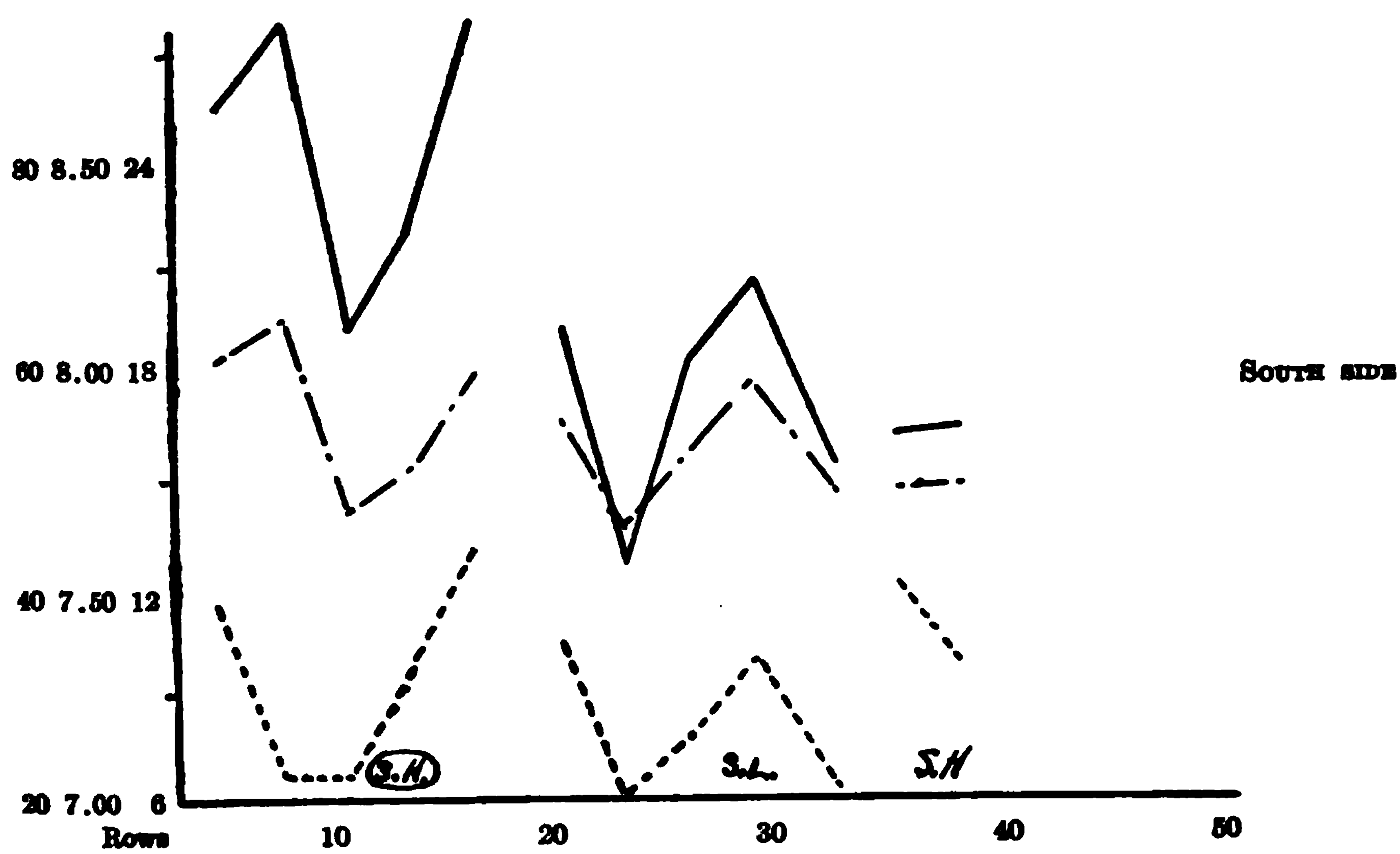
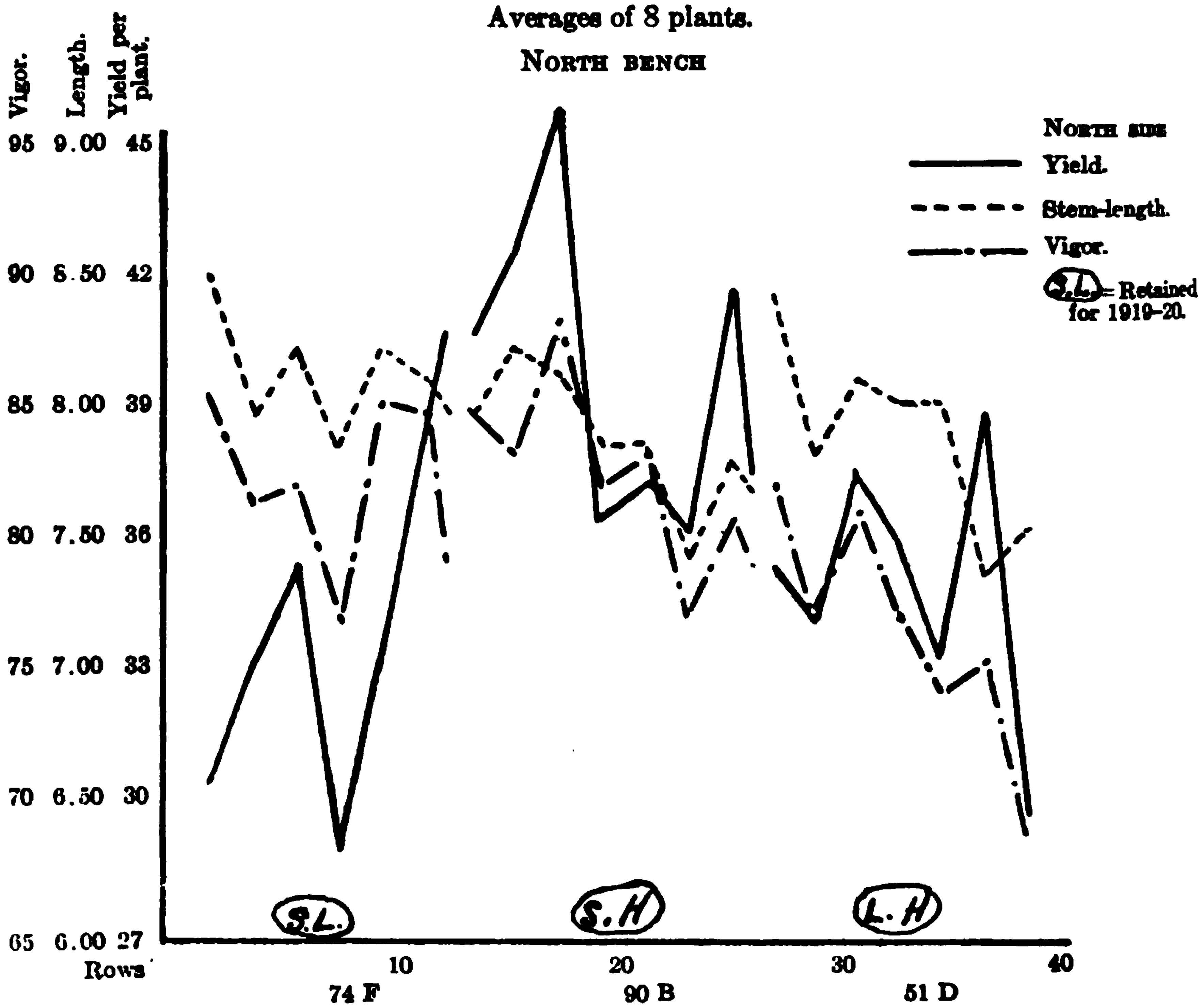


CHART XVI.— INFLUENCE OF LOCATION IN HOUSE ON YIELD, STEM-LENGTH, AND VIGOR, 1918–19.

Averages of 8 plants.

NORTH BENCH



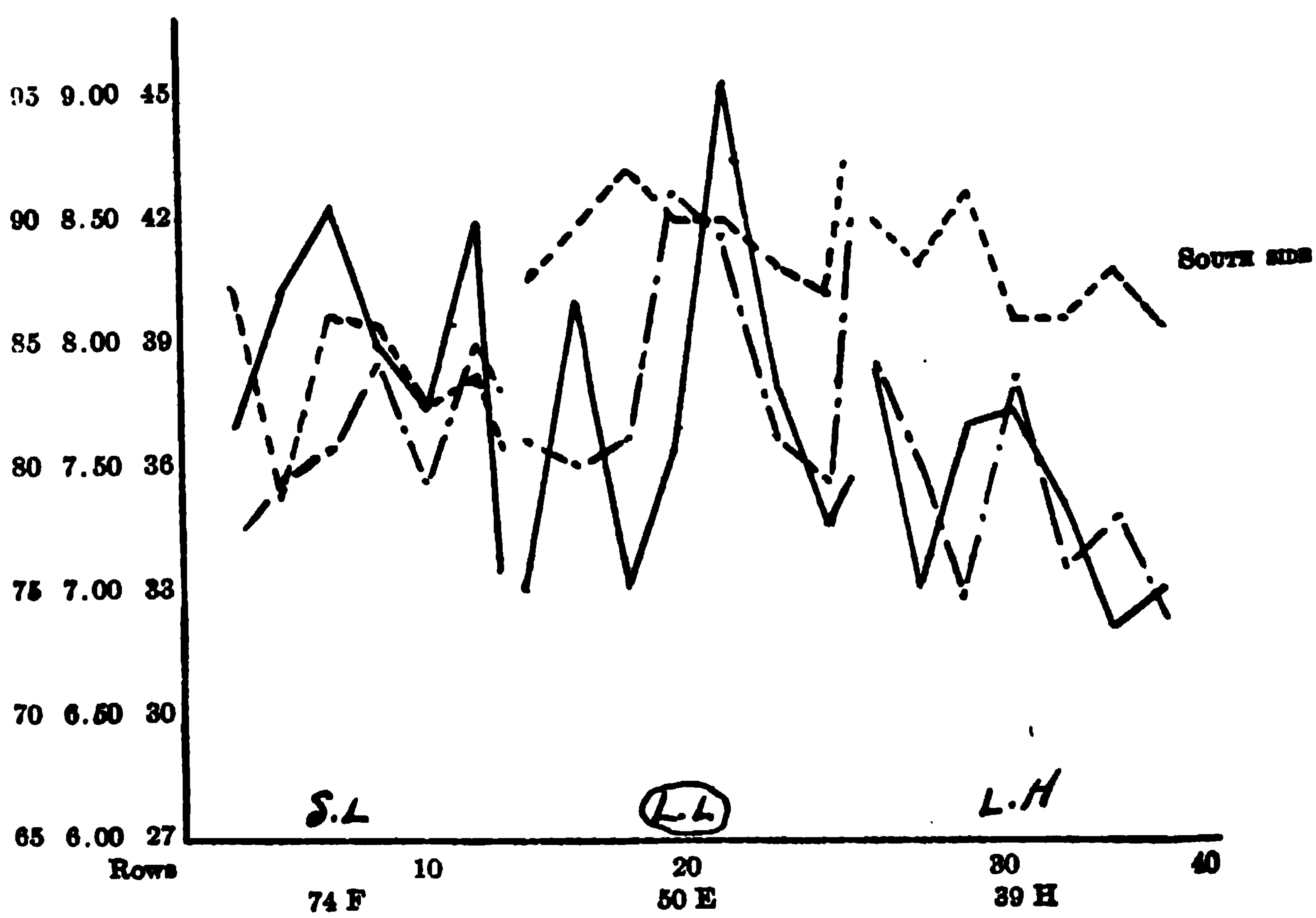
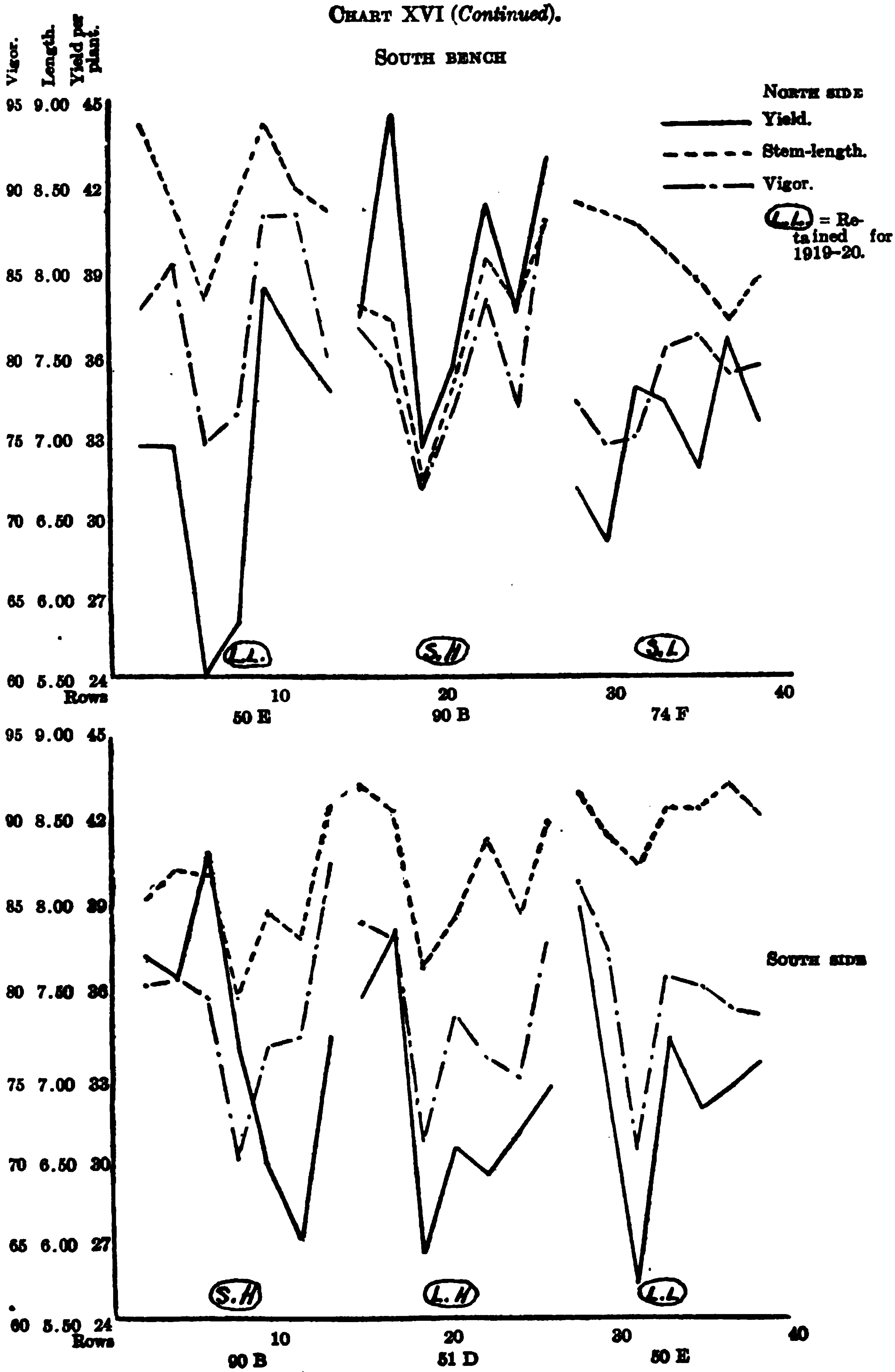


CHART XVI (*Continued*).

SOUTH BENCH



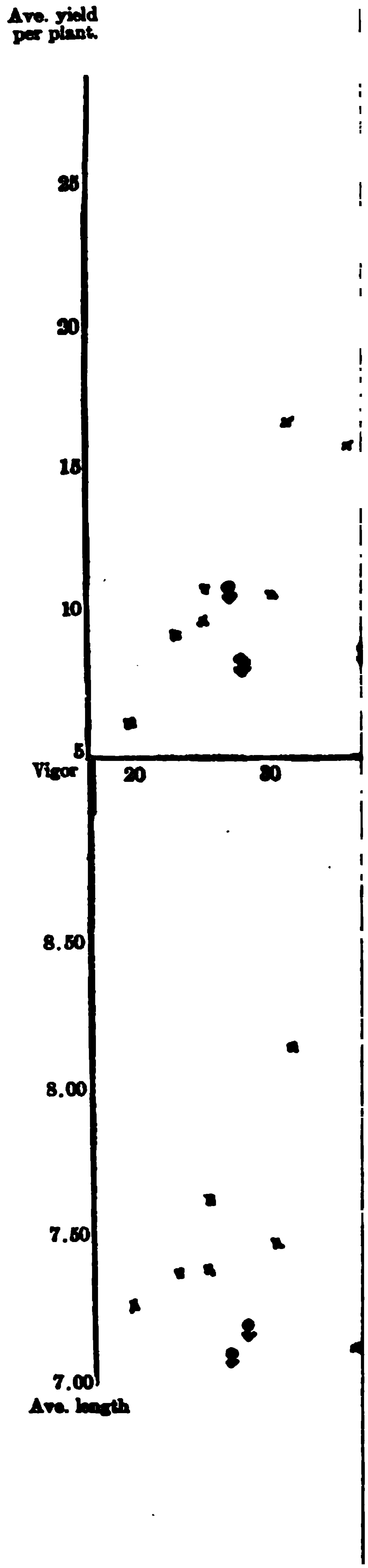
short-stem blossoms but, on account of the large number of blooms in the first harvest this year, it was decided to retain it in the records. Because of including these short stems, the average length has probably been decreased several tenths of a unit. In the third group of harvests, that extending from December 24 to January 31, a very considerable proportion of the plants averaged well above ten units in length. The average vigor this year was 81.447 ± .339. In other years it has been the custom to arrange the vigor scale in such a way that the average would be approximately 50, but this year such a large proportion of the plants showed extreme vigor that this did not seem advisable. Plants recorded as having a vigor of 50 per cent this year were probably fairly comparable with those having a similar vigor record last year.

Group yields.— In the long-stem selections, the high-yielding plants averaged 1.847 ± .754 blooms more than the low-yielding plants. (See Table II.) This is less than the difference between the same groups in the previous year. This fact may probably be considered as another indication that our process of selection is beginning to isolate distinct groups because this year there are progeny of only two of the original plants represented in the long-high group. One of these plants, 51 D, which is the clon retained to continue the selection for another year, is not strictly a high-yielding clon, but, from its performance of other years, would be graded as somewhat above the average. It is retained, however, because it is long-stemmed and is sufficiently high-yielding to answer the purpose. In the short-stem selection the high-yielding plants gave 4.970 ± .767 blossoms more than the low-yielding plants. This great difference in yield is due to the fact that 90 B, the short-high strain, is a remarkably high-yielding group.

Group lengths.— In the high-yielding strains the long-stem plants were .368 ± .046 units longer in blossom stem-length than the short-stem plants and, in the low-yielding strain, the difference was .346 ± .048. (See Table II.) These differences are not quite as great as in the previous year but, as before explained, this is due to the inclusion in the records of a large number of short-stem blooms in the first picking which in previous years were discarded.

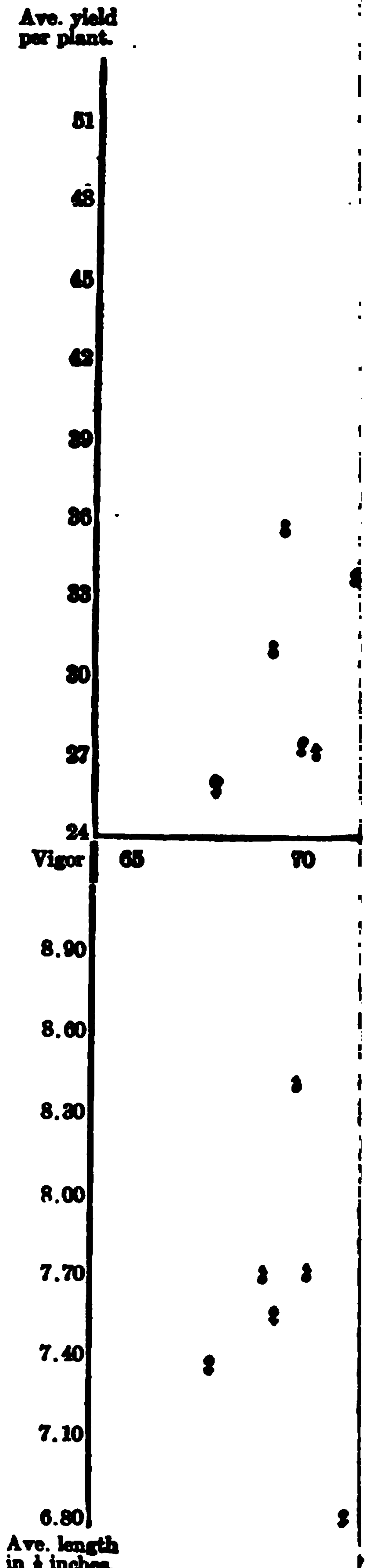
When the house was planted in the fall of 1918 the different lines were broken into groups, the groups being placed in different parts of the house. In all there were twelve groups. A study of these in Chart XVI shows that in seven cases the relative position of the graph of both stem-length and yield indicates clearly the type of the selection of that group. In each of the other five cases, the graph of either stem-length or yield is in the position to be expected from its types of selection while the other graph is either uncertain or apparently opposite to the selection. In two of these latter cases, the two groups of 74 F on the west end of the north bench, a possible

CHART XV.—



Ave. yield per plant.
25
20
15
10
5
Vigor
20
30
8.50
8.00
7.50
7.00
Ave. length

CHART XVII.—



If
of
f-
ie
is
ie

of
is
of
ll
ie

d
fi-
es
le
s.
is
ts

d
ly
is
ig

of
es
in
ie
n,
i-
it
h

e
ve
ke
y,
h-
is
an
to

cause for the failure to follow the selection may be suggested. If we refer back to Chart IX we see that with the mixed population of 1914–15, in the area occupied by these two groups, there was a different relation between the stem-length and yield lines than in the rest of the house. As has been suggested before, this difference is probably due to a slight change in the environmental factors in the northwest corner of the house.

The way in which the plants adhere to their respective types of selection is also shown in Chart XVII. Here the whole population is shown in groups of eight plants and the character of the selection of each group is graphically indicated. It is remarkable the small number of groups which fall in areas occupied by groups of the opposite selection.

CONCLUSION

The first five years of selection have isolated four well-defined groups. The differences between the opposite selections are sufficiently large to show graphically on the charts of the two benches for the fourth and fifth years and, in comparison with their probable errors, make it certain that they are not due to chance variations. It is believed that variations due to lack of uniformity of conditions within the house have been so nearly eliminated that the final results are not materially affected.

When this work was started it was the opinion of those connected with it that such a result as this would not be secured and probably most pomologists would have held the same opinion. For this reason there is justification in restating certain points and showing the possible application of the results.

During the five years reported in this publication, the process of selection has really been one of isolation whereby certain clonal lines have been selected out of the miscellaneous population purchased in 1914. In nearly every case each plant within the clon has been the parent of four plants used the following year. It follows, then, that we seemingly have proved only the existence of asexually inherited differences which probably were present before the experiment was begun. No attempt has been made to find when or how such differences arise.

That differences have been found in the violet which could be passed on from bud generation to bud generation does not prove that similar differences may be found in the apple but it does make it seem more probable that such differences exist. Unfortunately, from the standpoint of practical application, the labor and the technical difficulties involved in proving that an observed difference is really transmissable and not simply a temporary response to an environmental change make it seem inadvisable for a nurseryman to attempt such a problem.

The four selection groups now contain only five pure lines, each tracing back to a single plant in 1914. Whether these clonal lines are pure lines in the sense that Johannsen has applied that term or whether they are simply stages beyond which we will go to greater differences, thru further selection, is now the problem.

PLANS FOR CONTINUING THE EXPERIMENT

There had been no selection within any clonal line up to the spring of 1919. At that time it was decided that fifty parent plants would be saved in each of the four types of selection as this would give the 800 plants necessary to fill the house. In all but one type these fifty were selected from one clon only. As there were from 100 to 150 plants from which to select the fifty parent plants this afforded an opportunity to choose those plants which best answered the conditions of their particular type. Instead of selecting single plants, groups of four, each tracing back to a single parent the previous year, were selected.

In one group, the short-high selection, two plants were used to start two new lines in an attempt to break up a clon by selection within it. One of these plants was selected for long stem and the other for short stem. In choosing these, care was taken to find two plants which did not have a common origin until the original 1914 plant was reached. These two lines will be continued with intensive selection.

These general plans will be followed for another five years to test the fixity of the clonal lines.

ACKNOWLEDGEMENTS

Thruout the five years of the experiment Mr. Joseph Wellington has had the oversight of the propagation and the harvesting. This has involved a great deal of work and no small part of whatever value the work has is due to the care and accuracy with which the records were taken in the greenhouse. He has also assisted in the preparation of the data for publication.

The author is greatly indebted to Dr. H. H. Love of the Department of Plant Breeding of the New York State College of Agriculture for many helpful suggestions and advice in the biometrical work.

The initiation of this work was due to Dr. U. P. Hedrick. For many years he had been interested in the question of pedigree in fruit and saw the possibilities in extending this study to some plant where results could be secured more rapidly than with the apple. His direction has been one of the factors in the success of the work.

LITERATURE CITED

Stuart, Wm. 1915. Potato breeding and selection. U. S. D. A. Bul. 195.

Stout, A. B. 1915. The establishment of varieties in Coleus by the selection of somatic variations. Carnegie Inst. Wash. Pub. 218.

Dorsey, M. J. 1916. The inheritance and permanence of clonal varieties. Proc. Am. Soc. Hort. Sci. 1916.

Jennings, H. S. 1916. Heredity, variation and the results of selection in the uniparental reproduction of *D. flugia corona.* Genetics, 1 No. 5.

Babcock, E. B. and Clausen, R. E. 1918. Genetics in relation to agriculture. McGraw-Hill. New York.

Shamel, A. D., et al. 1918. Citrus fruit improvement. U. S. D. A. Buls. 623, 624, 697.

APPENDIX

TABLE IV.—CORRELATION OF YIELD AND LENGTH OF STEM.*

Total for entire house, 1914–15.

Stem-length.† Class Ave.	Yield. 2	5	8	11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	56	59	Totals.
10.51								1													1
10.31										1											1
10.11				2								1									3
9.91									1		3	1	1	4	2	3	1				16
9.71		1			2		1	1	1	2	6	2	1	3	2		1	2	1	1	27
9.51				1		2	5	2	4	6	9	4	8	6		4	1		1		53
9.31			2	1		2	4	8	8	7	13	9	10	6	2	4	1	1		1	79
9.11		1		2	3	8	7	9	9	11	12	9	6	9	7	4		3	1		101
8.91		2	1	2	2	6	11	15	13	16	8	9	10	7	7		1				110
8.71		1	1	4	1	3	11	17	11	13	18	10	8	3	2	1	1	1		1	107
8.51		1	1	8	5	8	14	12	12	7	10	8	4	2	1	1					94
8.31	1		4	2	3	9	10	11	10	9	3	3	2	3	2	1					73
8.11		2	1	3	8	4	6	7	5	5	2		1								44
7.91	1	1	2	1	4	1	1	3	1	2	2										19
7.71	1		2		2		2			1											8
7.51				1		2			1												4
7.31																					0
7.11			1	1																	2
Totals.	3	9	15	28	30	45	72	86	76	80	86	56	51	43	25	18	6	7	3	3	

$r = .415 \pm .019$

* In the correlation tables it has been more convenient to arrange the factors studied with their highest values at the top of the table and because of this a positive correlation is shown by an ascending population.

† Blossom stem lengths are given in units of one-half inch.

TABLE V.— CORRELATION OF VIGOR AND STEM-LENGTH.

Total for entire house, 1915–16.

STEM-LENGTH.

VIGOR. CLASS AVE.	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	TOTALS.
100																1		1			1			3
95																1	2		1	1				5
90													1	1	1	1	2	1	1	3				11
85															1	2	1	4	2			1		11
80								1						2		3	3	4	3		2			18
75													1	3	5	4	3	3	2	6			1	28
70														1	4	4	5	2	3	3		2		24
65												2	2	4	5	4	7	5	4	2	1	2		38
60												2	3	6	4	12	6	6	3	2	1			45
55											1	3	4	9	10	3	6	4	2	2			1	45
50											4	10	13	6	10	15	7	3	1					69
45						1		1	3	3	4	9	10	4	6	11	9	4	1					66
40						2		1	2	6	9	10	12	5	4	9	1	2	1					64
35						1	2	1	5	7	8	15	11	11	4	1	2							68
30					1	1	1	3	6	6	8	3	5	4	3	1								42
25						2	2	4	3	3	2	1	1											18
20					2		2	2	1				1											8
15				2	1	2		2		3		1												11
10	2			1	1	1	1			1														7
TOTALS.	2	0	0	3	5	10	8	15	20	29	36	56	64	56	57	72	54	39	24	19	5	5	2	

$r = .807 \pm .009$

TABLE VI.—CORRELATION OF VIGOR AND YIELD.

Total for entire house, 1915–16.

YIELD.

	CLASS AVE.	11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	56	59	62	65	68	71	74	TOTALS.
VIGOR.	100														1	1			1					3
	95										1		1	1			1				1			5
	90									1	3	2	1		2			1	1					11
	85								2		1	1	1	1	1		2				1		1	11
	80								1			6	1	2	4	1		2				1		18
	75							1	3	4	3	4	3	5	1	2	1	1						28
	70				1			2	1	2	3	6		4	3	2								24
	65					1		2	5	7	3	5	9		4			1		1				38
	60				1	2	3	3	6	4	2	7	9	2	3	2		1						45
	55					2	3	3	5	6	7	5	5	2	5	2								45
	50					2	7	11	9	8	12	13	3	1	2			1						69
	45				2	9	4	7	10	13	8	9	1	3										66
	40			2	5	7	9	16	13	7	2	1	1	1										64
	35		1	2	10	10	19	13	9	3			1											68
	30		1	8	10	11	8	2	2															42
	25	1	1	8	4	1	1	2																18
	20	2	2	2		2																		8
	15		4	5	2																			11
	10	2	4	1																				7
	TOTALS.	5	13	28	35	47	54	62	66	55	45	59	36	22	26	10	4	7	2	1	2	1	1	

$r = .739 \pm .012$

TABLE VII.— CORRELATION OF YIELD AND STEM-LENGTH.

Total for entire house, 1915–16.

YIELD.

CLASS AVE. (STEM-LENGTH.)	11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	56	59	62	65	68	71	74	TOTALS.
10.40																1							1
10.20									1								1	1				1	4
10.00									1		4			1	1		2						9
9.80								3			1	2	2	2	1	1					1		13
9.60							2		4	3	5	2	1	6		2		1	1	2			29
9.40							2	3	3	2	7	10	3	3	2	1	1						37
9.20				1			5	6	5	4	4	7	4	4		1	1						42
9.00				1	1	5	10	9	7	6	18	2	5	9	3		1						77
8.80			1	3	4	4	7	12	17	12	5	3	4	2									74
8.60				1	2	9	8	5	1	6	4	5	2	1	1								45
8.40			3	7	3	11	9	12	8	5	5	2	1										66
8.20		1	2	3	9	9	11	7	5	6	1	1	2										57
8.00			3	4	12	5	4	2	2	1	1												34
7.80	1	1	3	4	5	7	1	5			1												28
7.60	1		6	2	6	3	2		1		1		1										23
7.40		4	5	4	2		1																16
7.20	2			3	1	1			1														8
7.00		3	2	1		1	2																9
6.80	1	2	1		1																		5
6.60		1																					1
6.40																							0
6.20		1	1																				2
6.00																							0
TOTALS.	5	13	27	34	46	55	64	64	56	45	57	34	25	28	8	6	6	2	1	2	1	1	

$r = .729 \pm .012$

TABLE VIII.—CORRELATION OF VIGOR AND STEM-LENGTH.

Total for entire house, 1916–17.

STEM-LENGTH.

VIGOR. CLASS AVE.	6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	9.91	10.11	TOTALS.
100																	1			1
95												1			1	1		2		5
90										2		2	2	1	4	8	3	1	2	25
85							1					1	1	8	2	2	2			17
80								1	1	3		1	5	5	5	1	2			24
75									3	4	2	3	3	4	1	1	2	1		24
70					1	1				2	7	4	5	9	5	1				35
65							1	1	3	5	10	5	8	9	5	1				48
60			1				1	1	9	5	8	6	5	11	10	2				59
55						1	4	5	13	9	8	9	4	10	5	1				69
50	1			1			7	5	9	10	13	10	5	6		2	1			70
45						3	4	5	15	12	12	6	1	5	1	1				65
40				1	2	7	8	6	12	17	9	10	3	6						81
35				1	3	4	2	6	9	6	5	4		1						41
30			1	1		2	11	5	9	5	2	3								39
25	1			1		3	6	1	2	5	3									22
20				1	1	1	3	2	2	1										11
15						2		1												3
TOTALS.	2	0	2	6	7	24	48	30	87	86	79	65	42	75	39	21	11	4	2	

$r = .611 \pm .016$

TABLE IX.—CORRELATION OF VIGOR AND YIELD.

Total for entire house, 1916-17.

YIELD.

VIGOR. Class Ave.	5	8	11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	56	59	62	65	68	71	Totals.
100																1								1
95													1	1	1	1				1				5
90								2			1		2	1	3	6	2	3	1	3		1		25
85											2	1	2	4	3	1	1		1	1			1	17
80								1	1			1	4	5	4	6	1	1						24
75					1				1	1	2	2	7	2	2	3	1		1	1				24
70							2		4	5		3	6	4	5	1	1	3		1				35
65							1		6	8	5	7	9	3	4	3		1	1					48
60			1			1	2	4	5	10	12	12	6	2	2				2					59
55						4	5	2	11	11	13	9	5	6	3									69
50		3			1	3	8	8	12	12	7	6	8	1		1								70
45					3	2	14	13	17	6	7	1	1	1										65
40		1	2	4	4	9	19	12	16	3	8	1	1		1									81
35			4	2	2	8	10	8	4	1	1	1												41
30			4	3	14	8	6	2	2															39
25			2	5	7	4	2	1		1														22
20		4	1	2	3	1																		11
15	1	1	1																					3
Totals.	1	9	15	16	35	40	69	53	79	58	58	44	52	30	28	23	6	8	6	7	0	1	1	

$r = .793 \pm .009$

Table X.— Correlation of Yield and Stem-length.

Total for entire house, 1916–17.

Stem-length.

Yield. Class Ave.	6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	9.91	10.11	Totals.
71																	1			1
68																		1		1
65																				0
62													1	1	2	1	1		1	7
59														2	2	1	1			6
56											2		3		1		2			8
53									1				1	2	1	1				6
50									1	3		1	3	4	4	4	2		1	23
47							1		2	3	3	3	3	4	3	4		2		28
44									4	4	2	3	1	11	4	1				30
41						1	1	1	1	2	7	8	7	11	5	4	3	1		52
38							2		4	5	5	7	4	10	6	1				44
35						1	1	3	7	10	9	7	5	8	3	4				58
32							2	3	9	6	12	10	7	8			1			58
29			1			3	4	5	16	10	12	13	3	6	6					79
26					2		5	1	12	17	8	4	1	3						53
23				1	2	6	6	12	8	14	11	3	1	3	2					69
20					1	1	7	4	11	7	3	4	1	1						40
17				2	1	4	12	2	8	2	2	1	1							35
14				2		3	3	4	2	1	1									16
11	1		1	1	1	2	1	3		1	2	1		1						15
8	1					3	3		1	1										9
5								1												1
Totals.	2	0	2	6	7	24	48	39	87	86	79	65	42	75	39	21	11	4	2	

$r = .716 \pm .012$

TABLE XI.— CORRELATION OF VIGOR AND STEM-LENGTH.

Total for entire house, 1917–18.

STEM-LENGTH.

Vigor. Class Ave.	5.41	5.61	5.81	6.11	6.31	6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	Totals.
100										1	2	1	1	3	2	5	1	2	2	1		2	23
90										1	3	7	7	12	4	6	3	2	2				47
80									1	3	3	10	5	16	6	3	1	2					50
70							3	2	12	5	14	10	8	19	8	3		1					85
60						1	5	3	13	12	11	9	7	11	4	1	1		1				79
50	1					2	4	2	18	15	21	16	12	16	2		1						110
40				1	3	7	6	10	26	20	23	18	9	6	2		1						132
30		1		1	1	2	2	6	12	18	23	12	1		1								80
20			3	1	3	9	14	8	16	8	7	4	2										75
10						1				1													2
Totals.	1	1	3	3	7	22	34	31	98	84	107	87	52	83	29	18	8	7	5	1	0	2	

r = .600±.016

TABLE XII.—CORRELATION OF VIGOR AND YIELD.

Total for entire house, 1917–18.

	CLASS AVE.	YIELD. 2	5	8	11	14	17	20	23	26	29	32	35	38	41	TOTALS.
VIGOR.	100					4	3	4	3	5	1	2			1	23
	90			1	2	6	8	10	7	7	3		1	1	1	47
	80			1	3	6	5	12	9	7	2	3	1	1		50
	70			1	15	13	11	16	14	8	3		3		1	85
	60		1	2	15	13	8	20	9	6	3	1	1			79
	50		1	9	22	24	18	10	11	9	2	2	2			110
	40		5	11	30	34	19	18	6	7	2					132
	30		4	13	22	19	12	8	1	1						80
	20	3	19	22	16	10	5									75
	10	1		1												2
TOTALS		4	30	61	125	129	89	98	60	50	16	8	8	2	3	

$r = .550 \pm .017$

TABLE XIII.— CORRELATION OF YIELD AND STEM-LENGTH.

Total for entire house, 1917-18.

STEM-LENGTH.

Yield. Class Ave.	5.41	5.61	5.81	6.11	6.31	6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	Totals.
41											2	1											3
38												1				1							2
35									1	4	1	1		1									8
32									1	1	3			1				1				1	8
29					1					4		2	1	2	3	1		1	1				16
26						1		1	9	5	3	7	5	13	1	3		1	1				50
23							4	4	5	2	10	7	2	10	7	4	2	1		1		1	60
20						1	1	1	12	9	17	14	9	20	6	4	2	1	1				98
17	1					2	3	2	9	9	18	13	8	12	4	2	3	2	1				89
14					2	3	5	3	17	23	23	15	16	13	5	3			1				129
11			1	2		3	5	10	23	18	23	22	6	9	2		1						125
8				1		4	11	5	16	9	4	4	4	2	1								61
5		1	1		4	7	5	4	5		3												30
2			1			1		1					1										4
Totals.	1	1	3	3	7	22	34	31	98	84	107	87	52	83	29	18	8	7	5	1	0	2	

$r = .387 \pm .021$

TABLE XIV.—CORRELATION OF VIGOR AND STEM-LENGTH.

Total for entire house, 1918–19.

STEM-LENGTH.

VIGOR. Class Ave.	6.31	6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	9.91	10.11	TOTALS.
100										1	4	4	4	9	9	6	8	2	1		48
95								1	3	2	9	13	15	10	12	12	8	3			88
90						1	1	2	11	9	19	19	18	12	14	1	6	1		1	115
85					1	2	9	12	11	26	20	22	19	6	4	1	2				135
80				1	2	8	12	15	12	14	18	10	8	2	2	1					105
75			1	1	1	8	6	15	9	12	9	7	3	1		1					74
70	1			1	2	3	6	5	4	11	3	2	3		1						42
65				3		2	3	4	3	5	1	1	1	1							24
60			1	1	1	5	3	1	1	1	4	2			1						21
55		1	1	3		4	3	3	1		1										17
50				1	2	3	1		2	1											10
45							4	1	1	1		1									8
40			1	2	1	2	1		1												8
35				1																	1
30								2													2
25				1																	1
TOTALS.	1	1	4	15	10	38	49	61	59	83	88	81	71	41	43	22	24	6	1	1	

$r = .554 \pm .017$

TABLE XV.— CORRELATION OF VIGOR AND YIELD.

Total for entire house, 1918–19.

YIELD.

CLASS AVE. (VIGOR.)	8	11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	56	59	62	65	68	71	TOTALS.
100									1		3	2	5	8	5	10	5	3	2	2		2	48
95						1	3	2	3	10	6	10	14	13	9	10	2	3	1		1		88
90						5	2	4	7	12	17	17	18	14	3	10	3	1	2				115
85				1	2	8	9	9	20	26	16	15	6	11	6	1	4	1					135
80				1	6	6	9	12	14	9	19	14	5	4	4	2							105
75				1	4	9	12	11	10	9	7	3	5		1	1	1						74
70			1	2	1	6	11	5	6	4	1	4				1							42
65				1	2	3	3	4	3	1	5	1		1									24
60			1	4	2	5	1	1	3		2	1			1								21
55	1	1	3	1	4	2	4		1														17
50				4	1	2	1	2															10
45		1	1	1	2	1	1			1													8
40			2	3	2	1																	8
35		1																					1
30			1				1																2
25				1																			1
TOTALS.	1	3	9	20	26	49	57	50	68	72	76	67	53	51	29	35	15	8	5	2	1	2	

$r = .628 \pm .012$

TABLE XVI.—CORRELATION OF YIELD AND STEM-LENGTH.

Total for entire house, 1918–19.

STEM-LENGTH.

Yield. Class Ave.	6.31	6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	9.91	10.11	Totals.
71															1			1			2
68												1									1
65											2										2
62											1			1	1		2				5
59										1	1	4	1			1					8
56								1	1	1	2	3	2	4	1						15
53						1		2	1	2	3	5	5	4	6	3	2			1	35
50			1			2	1	1	3	4	3		3	3	3	1	2	1	1		29
47							1	3	2	3	9	5	7	7	5	5	3	1			51
44						2	1	3	5	7	7	6	9		8	2	3				53
41						1	4	9	6	7	12	11	6	3	2	2	3	1			67
38				2	1	3	7	8	5	11	13	5	8	4	5	1	2	1			76
35					1	3	7	5	11	11	7	12	2	5	4	1	3				72
32				1		3	3	6	7	8	7	10	13	4	3	1	1	1			68
29				2		3	5	4	6	12	8	1	3	2	1	2	1				50
26					2	7	5	12	4	6	4	4	6	2	2	2	1				57
23				1	4	3	5	4	6	4	4	10	5	1	1		1				49
20		1		2	1	5	5	2	1	4	2	1	1	1							26
17			2	4	1	3	3		1	2	1	2				1					20
14	1			2		2	1	1			2										9
11				1			1					1									3
8			1																		1
Totals.	1	1	4	15	10	38	49	61	59	83	88	81	71	41	43	22	24	6	1	1	

r = .379 ± .021

TABLE XVII.—CORRELATION OF VIGOR AND STEM-LENGTH.

Long-high group, 1918–19.

STEM-LENGTH.

Vigor. Class Ave.	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	9.91	10.11	Totals.
100									1			1		1				3
95							1	5	3	2	3	1	3	5	1			24
90						3		5	1	3	2	5		3			1	23
85						1	5	5	6	6	2	1		1				27
80				2	1	1	5	6	4	3	1							23
75				1	7	4	2	6	5									25
70		1	1	1	1	2	6	2	1									15
65					1	2	3	1										7
60			1				1	2										4
55				2	1	1		1										5
50	1		1			1												3
45				1	1	1												3
40		1		1														2
35																		0
30					1													1
Totals.	1	2	3	8	13	16	23	33	21	14	8	8	3	10	1	0	1	

$r = .645 \pm .030$

TABLE XVIII.—CORRELATION OF VIGOR AND YIELD.

Long-high group, 1918–19.

YIELD.

VIGOR. CLASS AVE.	11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	56	59	TOTALS.
100												2				1		3
95						1		2	1	2	4	5	6	2		1		24
90						1	1		1	5	3	3	3	2	4			23
85					1	1	2	6	3	4	3	1	6					27
80			1		2	2	4	3	1	5	3	1	1					23
75				1	3	7	4	6	1		2	1						25
70			1		2	4	2	2	3						1			15
65						1	1	1	1	2	1							7
60					1	1				1				1				4
55	1	1			1	2												5
50			2				1											3
45			1	1		1												3
40			1	1														2
35																		0
30						1												1
TOTALS.	1	1	6	3	10	22	15	20	11	19	16	13	16	5	5	2	0	

$r = .655 \pm .030$

Table XIX.— Correlation of Yield and Stem-length.

Long-high group, 1918–19.

Stem-length.

Yield. Class Ave.	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	9.91	10.11	Totals.
56									1		1							2
53					1					1	1			1			1	5
50						1		2				1		1				5
47						1	1	4	3	3	2		1	1				16
44						1	1	2	2	2		3		2				13
41					1	2	4	3	2			1	2	1				16
38							5	5	1	2	1	3		1	1			19
35				1		2	2	1	3		1			1				11
32					1	2	4	5	4	3	1							20
29					3	3	2	4	1	1	1							15
26		1	2	1	6	3	2	3	1	1	1			1				22
23				2		1	2	2	2					1				10
20				2	1													3
17	1	1	1	1				1	1									6
14								1										1
11				1														1
Totals.	1	2	3	8	13	16	23	33	21	13	9	8	3	10	1	0	1	

$r = .461 \pm .040$

TABLE XX.—CORRELATION OF VIGOR AND STEM-LENGTH.

Long-low group, 1918–19.

Vigor. Class Ave.	Stem-length. 6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	Totals.
100									1	1	2	4	3	5	3	1	20
95										3	1	3	4	4	3	2	20
90							1	2	4	7	7	3	4	1	3	1	33
85				1			3	4	6	7	9	3	2		1		36
80					1	2		2	5	1	4	1	2	1			19
75				1		1	1	3	1	2	2	1		1			13
70					1	1		2			1		1				6
65				1		1		2		1	1						6
60	1			1					2	2							6
55		1			1												2
50							1	1									2
45					2			1									3
40		1		1			1										3
35		1															1
30						1											1
Totals.	1	3	0	5	5	6	7	17	19	24	27	15	16	12	10	4	

$r = .655 \pm .029$

TABLE XXI.— CORRELATION OF VIGOR AND YIELD.

Long-low group, 1918–19.

Vigor. Class Avs.	Yield. 11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	56	59	62	Totals
100								1		2	1	1	5	3	4	1	1	1	20
95						1	1		2	1	2	3	5		4	1			20
90					2	1	2	4	4	6	4	4	5					1	33
85				2	2	3	4	9	7	2	3	1	2	1					36
80				2	2	2	2	3	1	3	3	1							19
75			1	2	2	2	3		3										13
70						3		1		1	1								6
65				1	2		1	1		1									6
60		1	2	1	1			1											6
55		1	1																2
50			2																2
45		1		1	1														3
40		2		1															3
35	1																		1
30		1																	1
Totals.	1	6	6	10	12	12	13	20	17	16	14	10	17	4	8	2	1	2	

r = .733 ± .023

TABLE XXII.—CORRELATION OF YIELD AND STEM-LENGTH.

Long-low group, 1918–19.

STEM-LENGTH.

YIELD. CLASS AVE.	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	TOTALS.
62												1			1		2
59											1						1
56											1	1					2
53										3			2	2	1		8
50											1	1	1			1	4
47								1	2	1	2	3	2	3	2	1	17
44								1	1	2			4	2			10
41						1	1		3	4	2	1			1	1	14
38					1	1		2	2	1	3	2	2	1	1		16
35				1			2	2	4	4	1		1		2		17
32					1				2	1	9	2	3		1	1	20
29							1	5	1		2	1		2	1		13
26						1		3		2	3	1	1	1			12
23					1	2	1		1	4	2	1					12
20				3			1	2	2	1		1					10
17	1				1		1	1		1				1			6
14		2		1	1	1			1								6
11		1															1
TOTALS.	1	3	0	5	5	6	7	17	19	24	27	15	16	12	10	4	

$r = .515 \pm .037$

Table XXIII — Correlation of Vigor and Stem-length.

Short-high group, 1918–19

Vigor. Class Ave.	Stem-length. 6.31	6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	9.91	Totals.
100											2	1	2	3	2		2	1	1	14
95											3	2	7	3	3	2				20
90						1	1	1	5	3	7	4	4	3	2					31
85							3	9	3	9	6	6	2			1				39
80				1		4	4	7	5		2	2								25
75						3	2	5	1	1										12
70	1				1		4	3	1				1							11
65				2			3		1											6
60				1		1	2		1											5
55				1		2		1												4
50					2	1														3
45							1													1
40				1																1
Totals.	1	0	0	6	3	12	20	26	17	13	20	15	16	9	7	3	2	1	1	

$r = .660 \pm .028$

TABLE XXIV.—CORRELATION OF VIGOR AND YIELD.

Short-high group, 1918–19.

Vigor. Class Ave.	Yield: 14	17	20	23	26	29	32	35	38	41	44	47	50	53	56	59	62	65	68	71	Totals.
100											1	2	2	3	2		1	1		2	14
95										2	3	1	6	4		2	1		1		20
90						1	1	2	4	5	7	4		5	1	1					31
85				2	1	2	2	9	2	8	2	3	3	1	3	1					39
80				1	2	1	4	4	4	2	2	1	3	1							25
75				1	1	1			4		3			1	1						12
70	1	1		1	3	1		1		3											11
65				1		2			2			1									6
60				1		1	1		1	1											5
55			2		1		1														4
50				1	1	1															3
45								1													1
40		1																			1
Totals.	1	2	2	8	9	10	9	17	17	21	18	12	14	15	7	4	2	1	1	2	

$r = .642 \pm .029$

TABLE XXV.— CORRELATION OF YIELD AND STEM-LENGTH.

Short-high group, 1918–19

STEM-LENGTH.

Yield. Class Ave.	6.31	6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	9.71	9.91	Totals.
71															1			1		2
68												1								1
65											1									1
62											1						1			2
59											1	2				1				4
56								1		1	1	2		2						7
53						1		1		2	3	1	3	2	2					15
50						1	1		2	2			2	2	1	1	1		1	14
47							1	3			2	1	2	1	2					12
44						1	1	2	3	2	3	1	5							18
41							4	5	1	1	2	3	3	1	1					21
38				2		2	2	4	4		3									17
35						1	4	2	3	3	2	1		1						17
32							1	3	2	1		2								9
29				2		2	3	1		1	1									10
26					1	2	1	3	1							1				9
23					2	1	1	1	1			1	1							8
20				1		1														2
17				1			1													2
14	1																			1
Totals.	1	0	0	6	3	12	20	26	17	13	20	15	16	9	7	3	2	1	1	

$r = .536 \pm .036$

TABLE XXVI.—CORRELATION OF VIGOR AND STEM-LENGTH.

Short-low group, 1918–19.

STEM-LENGTH.

Vigor. Class Ave.	6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	Totals.
100									1	1	1		2	3	1	2	11
95							1	3	1	1	5	5	1	4	3		24
90							1	2	4	3	7	4	4	3			28
85				1	1	6	3	4	8	3	3	2	1	1			33
80				2	4	5	5	6	7	5	3	1					38
75		1	1	1	4	3	2	3	6	2		1					24
70			1		2			1	3	1	1	1					10
65			1		1		2						1				5
60				1	2	1	1							1			6
55	1	1	1		2		1										6
50					1	1											2
45											1						1
40		1			1												2
35																	0
30																	0
25			1														1
Totals.	1	3	5	5	18	16	16	19	30	16	21	14	9	12	4	2	

$r = .480 \pm .036$

TABLE XXVII.— CORRELATION OF VIGOR AND YIELD.

Short-low group, 1918–19.

YIELD.

VIGOR. Class Ave.	8	11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	56	59	62	65	Totals.
100											1	1	1	1		3	1	2		1	11
95						1	1	1	1	7	3	2	3	1	1	2		1			24
90						3			2	5	2	5	4	2	1	1	2		1		28
85				1		3	4	1	3	7	8	1	2		2		1				33
80					4	1	3	5	4	3	7	6	1	2	1	1					38
75					1	3	2	3	4	5	3	1	1		1						24
70					1	3	1	2	3												10
65				1	1		2		1												5
60				2	1	2			1												6
55	1		1		2	1	1														6
50					1	1															2
45		1																			1
40				1		1															2
35																					0
30																					0
25				1																	1
Totals.	1	1	1	6	11	19	14	12	19	27	24	16	12	6	6	7	4	3	1	1	

$r = .592 \pm .031$

TABLE XXVIII.—CORRELATION OF YIELD AND STEM-LENGTH.

Short-low group, 1918–19.

Yield. Class Ave.	Stem-length. 6.51	6.71	6.91	7.11	7.31	7.51	7.71	7.91	8.11	8.31	8.51	8.71	8.91	9.11	9.31	9.51	Totals.
65										1							1
62														1			1
59									1		2						3
56								1		1		1		1			4
53								1			1	1	1	2	1		7
50		1			1		1		2	1							6
47								1	1	1			1	1	1		6
44					1		1	1	3	1	1	2		1		1	12
41					1		2	2	2	4	2	1	1			1	16
38				1	1	4	3	1	4	3	3	3	1				24
35				1	1	2	3	4	4		4	1	3	3	1		27
32			1		3	1	2	3	3		3	1	1		1		19
29					1	2		2	4	2				1			12
26					3	3	2		1	1	1	1	1	1			14
23			1	2	2	1	1	3	2	1	3	2		1			19
20	1		1	1	1	3	1		2			1					11
17		1	2		2				1								6
14					1												1
11											1						1
8		1															1
Totals.	1	3	5	5	18	16	16	19	30	18	21	14	9	12	4	2	

$r = .377 \pm .041$

REPORT

ON

INSPECTION WORK

W. H. Jordan, *Director.*

L. L. Van Slyke, *Chemist.*

A. W. Clark, *Associate Chemist.*

M. P. Sweeney, *Assistant Chemist.*

Otto McCreary, *Assistant Chemist.*

W. F. Walsh, *Assistant Chemist.*

H. L. Winston, *Assistant Chemist.*

M. G. Moore, *Assistant Chemist.*

N. F. True, *Assistant Chemist.*

TABLE OF CONTENTS

REPORT ON INSPECTION WORK

INSPECTION OF COMMERCIAL FERTILIZERS, 1920

[Text of this Bulletin, No. 480, October, 1920, is omitted, since the data cease to have value before the Annual Report can be distributed.— W. H. JORDAN, *Director*.]

INSPECTION OF INSECTICIDES AND FUNGICIDES

[Text of this Bulletin, No. 481, December, 1920, is omitted, as the data cease to have value before the Annual Report can be distributed— W. H. JORDAN, *Director*.]

INSPECTION OF FEEDING STUFFS, 1920

[Text of this Bulletin, No. 482, December, 1920, is omitted, as the data cease to have value before the Annual Report can be distributed.— W. H. JORDAN, *Director*.]

APPENDIX

I. Popular Editions of Station Bulletins

II. Periodicals Received by the Station

III. Meteorological Records

POPULAR BULLETIN REPRINTS

NEGLECT OF DETAILS IN CARE OF MILKING MACHINES RESULTS IN LOW GRADE MILK*

J. D. LUCKETT

The milking machine and pure milk. The use of the milking machine with its rubber tubes, pail lid with milk spigots and valves, more or less complicated pulsator, and heavy pail, requires much greater care than the simple milk pails used in hand milking to insure the production of clean, pure milk of good keeping quality. While, in a sense, milk drawn by machines under proper conditions is cleaner than hand-drawn milk in that it is free from sediment and dust, if the accumulation of bacteria in the milky substance left in the poorly cleaned tubes is regarded as dirt (as it should be) the average machine-drawn milk is not as clean as hand-drawn milk. Since it is a simple matter to protect machine-drawn milk from outside dirt, the investigations described in the complete bulletin have to do with the difficulties actually met with by farmers in keeping milk drawn thru the milking machine free from excessive numbers of bacteria.

Station method of caring for machines. As a result of the ease with which milking machines become seeded with bacteria the Station has developed a method of caring for the machines which is essentially as follows: A rapid but *careful* washing of the machine by drawing thru it *immediately after each milking* successive pails of cold water, hot alkali water, and clear hot water; immersion of the teat-cups and all rubber parts in a good sterilizing solution between milkings, supplemented by a very thoro weekly overhauling of the teat-cups and tubes; and the *daily scalding and thoro drying* of all metal parts that come in contact with the milk

* Reprint of Popular Bulletin No. 472, April, 1920. The Complete Bulletin is reprinted on p. 119.

except those parts kept in the sterilizing solution. Parts kept in the sterilizing solution are rinsed in water before using them for milking. Good results have been secured with this method at the Station for more than ten years, but farmers in the vicinity of Geneva who have attempted to use similar methods of cleaning and caring for their machines have generally failed to obtain equally good results. An inspection of the dairies usually showed, however, that a lack of attention to details was responsible for the production of milk having excessive numbers of bacteria.

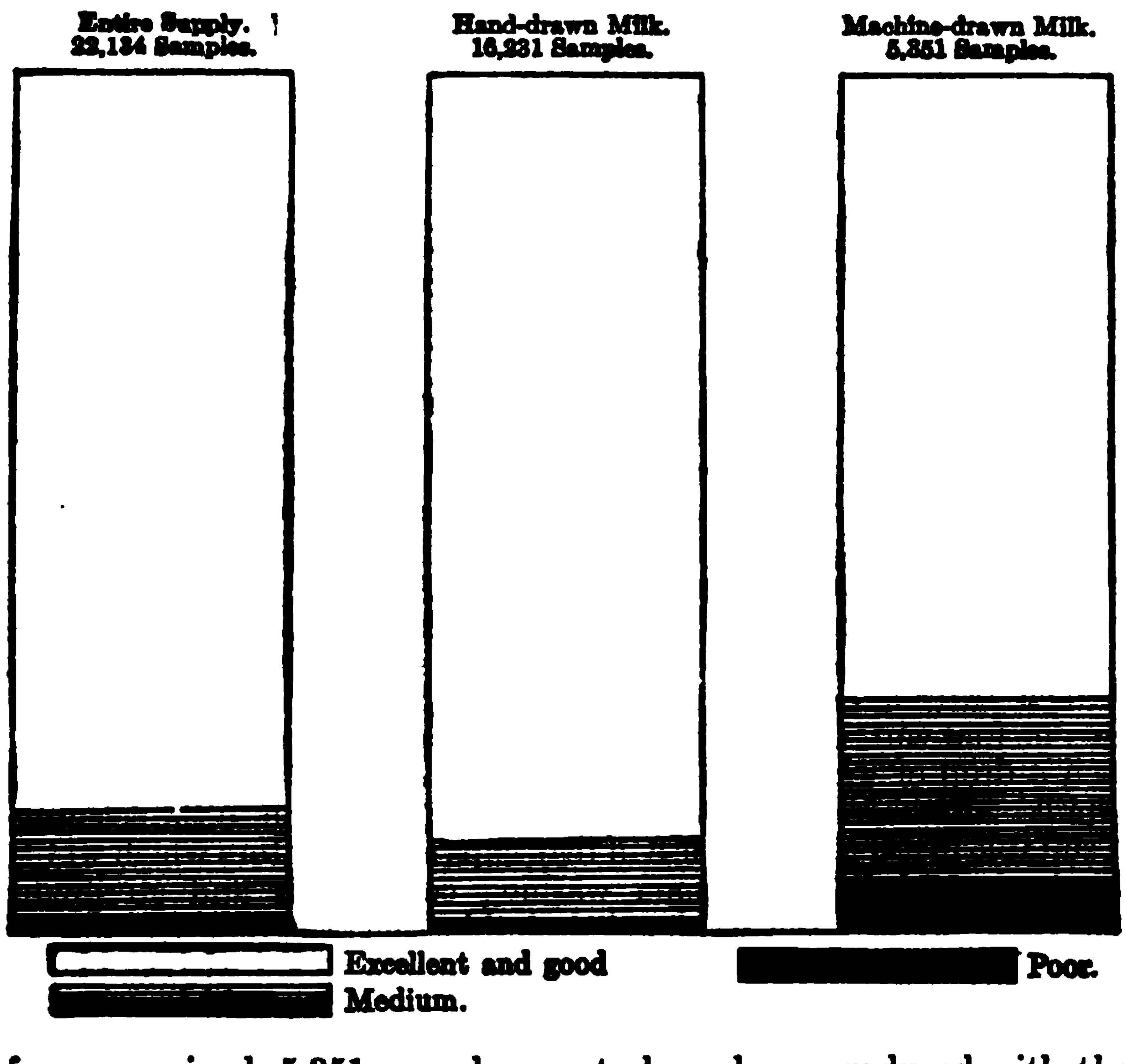
The hot water supply. The difficulty of obtaining an adequate supply of hot water in the barn or milk house frequently appears as a serious obstacle to milking machine users and prospective buyers. It has been found at the Station, however, that an abundance of hot water, *i.e.*, more than a tea kettle full, is necessary if the utensils are to be kept clean and essentially sterile. If the barn is equipped with running water, a hot water tank and heating coil can be installed, and the coil heated by means of a wood or coal stove, or a gas or kerosene burner. If running water is not available, the water may be heated in a large boiler on a wood, gas, or kerosene stove located in some safe place where the risk of fire is reduced to a minimum. Outfits for heating water are illustrated in Figs. 37, 38, and 39.

Fig. 37.— A Convenient Outfit for Heating Water with Wood.

Drying the utensils. Equal in importance to the use of plenty of hot water is the proper drying of all pails and pulsators. For this purpose it is suggested that drying racks be erected either in the open where the utensils may be inverted and exposed to a maximum of sunlight and fresh air with a minimum of dust, or that the racks be so arranged as to expose their contents to the heat of the fire used in heating the water.

Quality of Geneva milk as affected by machines. Since 1915 the Station has directed the milk control work for the city of Geneva and during that time 22,134 cans of milk have been examined in an estimation of the quality of the milk.[1] The milk is delivered by about sixty-five dairymen at two central receiving plants where it is pasteurized and bottled. Samples for bacteriological analysis and sediment tests are collected from the individual cans as received. Of the total number

CHART XVIII.— QUALITY OF GENEVA MILK SUPPLY, 1915-1919.



of cans received, 5,351 were known to have been produced with the aid of milking machines, and 16,231 by hand milking. Based on

[1] The grading of this milk has been made by direct microscopic examination. The term "excellent" has been applied to milk that would meet the bacteriological requirements for a Grade A raw milk under both the New York State and the New York City Codes. The terms "excellent" and "good" have been applied to milk that would satisfy the requirements for pasteurization as Grade A milk. The term "medium" has been applied to milk not acceptable for Grade A pasteurized but which would be accepted for Grade B pasteurized. Milk not fit for pasteurization as Grade B has been termed "poor."

the bacteriological content of the samples, 14,608 cans of the hand-drawn milk were graded as excellent or good, 1,396 as medium, and 227 as poor. Of the machine-drawn samples, 3,955 cans graded as excellent or good, 1,153 as medium, and 243 as poor. These differences are graphically illustrated on a percentage basis in Chart XVIII.

It is quite evident that the elimination of the milk brought from farms where milking machines were used would have materially improved the quality of the milk brought to the city.

Machine-drawn milk penalized. The amount of low grade milk brought from farms using machines was somewhat less than it otherwise would have been due to the fact that pressure was brought to bear on the men supplying this milk. In one instance the dairyman was forbidden to bring milk into the city because of his continued failure to keep his machine in a sanitary condition, while the premium paid for high-grade milk was frequently withheld from men using milking machines owing to the poor quality of their milk. The hand milker will continue to be a severe competitor of the milking machine until those who use machines secure as good quality milk as those who practice hand milking.

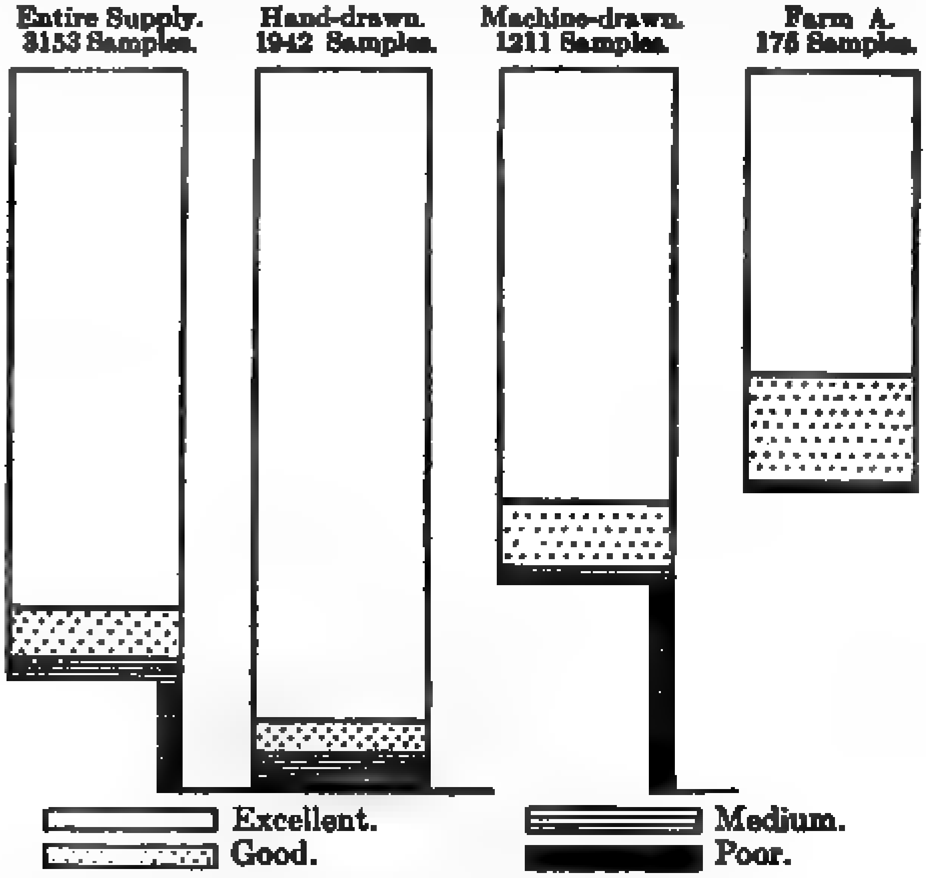
The milking machine not yet sanitary. Experience has shown that mechanically, the milking machine is reasonably successful, but from the standpoint of the control official the manufacturers have not yet given sufficient attention to the sanitary construction of their machines. Features which should receive special consideration include the elimination of all possible seams or crevices which serve to gather dirt, and the construction of leak-proof valves at the point which guards against possible leakage into the milk from the main vacuum line. This line cannot be cleaned satisfactorily with methods ordinarily available, and may become foul with milky vapor, condensation water, and like material, even a drop of which produces a detectable contamination in a pail of milk. Further study could also profitably be given to the selection of suitable metal alloys for use in teat-cups and pulsators which would not be corroded by common washing compounds and sterilizing solutions. It is also considered desirable that a standard grade of rubber be used for tubes and inflations which would withstand the action of animal fats and hot water, and which would have fairly uniform wearing qualities.

Practical experience with milking machines. Because of the failure of some nearby dairies to produce high-grade milk two farms were visited in order to make close observations of the methods followed in caring for the milking machines, and then to introduce such changes in the operation and cleaning of the machines as would guarantee the continuous production of good milk. A detailed account of the conditions found on the two farms is given in the complete bulletin,

together with a discussion of the satisfactory results obtained with milking machines on a third farm.

Inferior milk produced on Farm A. Considerable trouble had been experienced on this farm in producing milk with a low number of bacteria. Of the 175 cans of milk produced on the farm and examined prior to the beginning of the investigation, 94 had been graded as excellent, 26 as good, 38 as medium, and 17 as poor. When compared with the milk coming from all farms regardless of the method of production, as shown in Chart XIX, it will be seen that the milk from Farm A was

CHART XIX.— QUALITY OF MILK FROM FARM A AS COMPARED WITH THE QUALITY OF THE GENERAL MILK SUPPLY, AUGUST, 1918 TO MAY, 1919



decidedly below the average in quality, and that it was also much poorer than the average machine-drawn milk.

Improper care given machines. The dairy barn (Fig. 40) on Farm A was found to be fairly clean, large, light, and well ventilated, but the care given the milking machines was unsatisfactory. Two Empire units had been in use for some time. The tubes and cups were kept in a twenty-five gallon crock (Fig. 41) filled with a saturated brine solution plus a stock solution of chloride of lime. The solution was kept in good condition. As the tubes were placed in the solution, however, air was imprisoned in them with the result that the solution did not reach all the surface over which the milk passed, allowing bacteria which cause sour or

tainted milk to multiply and produce a bad odor in the tubes. Immediately after the morning milking a pail of cold water was drawn thru the tubes and pails, the one pail of water being used for both double units employed. The tubes and cups were then placed in the solution jar without further treatment. After breakfast the machine pails, pail lids, and strippings pails were taken to the house where they were washed with water that was sometimes nearly cold and then placed outside to dry. Following the afternoon milking a pail of cold water was drawn thru the machines and was generally followed by half a pail of fairly hot soda water and half a pail of clear warm water when the cups and tubes were again put into the solution, and the pails and lids turned upside down on a bench in the barn until milking time the next morning. Examination in the morning showed them still to be wet and greasy. Twice a week the machines were taken to the house for a thoro cleaning when they were taken entirely apart and washed.

Improved methods lowered the germ content.

Various modifications of the method of caring for the milking machines on Farm A were tried out during the first few days of the investigation in order to determine whether any one step was essential to the production of high-grade milk. The first corrective step taken was the removal of the screw cap at the end of the claw of the teat-cups before putting the cups into the sterilizing solution after each milking in order to allow the air to escape from the milk tubes and to insure the free passage of the solution thru the tubes. In other respects the care of the machines and utensils remained as usual. The quality of the milk varied considerably under these conditions.

The next procedure was to draw two pails of very hot water thru the milk tubes into the machine pails, thus thoroly scalding both the tubes and pails. The results were gratifying in that the four cans of milk produced under these conditions graded as excellent.

The use of a combined cooler and aerator served to produce a good quality of milk the first time it was used, but a gradual lowering in quality accompanied each successive cooling by this means probably due to the cooler being inefficiently cleaned. In other words, cooling alone is not sufficient to produce first-class milk if the utensils are not clean as the low temperature simply checks the growth of bacteria and does not reduce their numbers.

Station methods prove successful.

It was finally decided to follow in detail the methods so successfully used at the Station,[1] the treatment also including the milk cans and aerator. All of the twenty cans of milk produced under these conditions graded as excellent. From tests made during the course of the work it was evident that the chief source of

[1]Circular No. 54 (Revised), Milking Machines. 1918.

Fig. 38.— Outfits for Heating Running Water with Kerosene and Coal.

Fig. 39.— Outfit for Heating Running Water with Gas.

Fig. 40.— Farm A. Interior Dairy Barn.

Fig. 41.— Farm A. Solution Jar.

Fig. 42.— Farm B. Solution Jar.

Fig. 43.— Farm B. Interior Dairy Barn.

Fig. 44.— Farm C. Interior Dairy Barn. Solution Jar May be Seen in Background.

Fig 45.— Farm C. Solution Jar.

trouble on Farm A at that time was the metal utensils, and that scalding and drying these utensils resulted in the disappearance of excessive numbers of bacteria.

First cans may contain more bacteria than later cans of same milking. It was noticed in the examination of milk from dairies using milking machines that often a higher number of bacteria was found in the milk of one out of a number of cans containing milk from the same milking. The frequent recurrence of this fact led to the idea that the can with the large number of bacteria was probably the first can filled and that the milk had been contaminated by the first milk drawn thru the tubes and pails of improperly cleaned milking machines. In order to verify this assumption a record was kept of the order in which the cans were filled for several days at Farm A. The first one or two cans filled were found to have a higher number of bacteria than did the rest of the cans of the same milking, indicating that the first milk from the poorly cleaned milking machines and other utensils contaminated the first can or two.

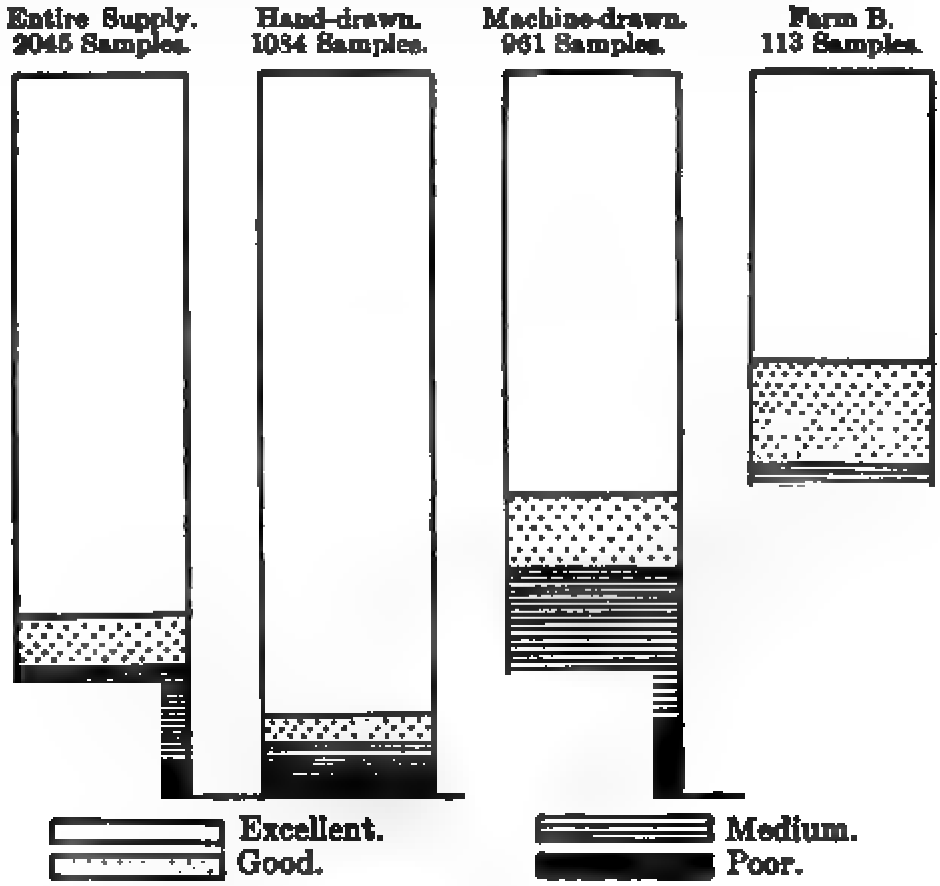
Age of milk affects quality. During the course of the work at this farm the dairyman raised the question as to why the morning milk usually graded higher than the afternoon milk when received at the milk plant despite the fact that the milking machines actually received less care previous to the morning milking than they did for the afternoon milking. It was pointed out that the afternoon milk was not sent to the receiving station until it was about sixteen hours old while the morning milk was received and graded when only about four hours old. The difference in time made a marked difference in the number of bacteria as the milk was not held at a temperature low enough to prevent the growth of bacteria. Samples of morning milk were held for sixteen hours and the grade determined at the end of that time, while samples of evening milk were graded when four hours old. When compared with evening milk of the same age, the morning milk was found to be of inferior quality.

Quality of Farm A milk improved. With the introduction of improved methods of caring for the milking machines and utensils, and so long as the dairy remained under observation, all the milk sent to Geneva was found to have a low germ content. During the next seven months (June to December) after the visit was made the quality of the milk from Farm A, while still variable, was better than that of the milk received previous to the visit.

It was concluded that the fluctuations in the quality of the milk produced on this farm were due to the failure on the part of the dairyman to attend to all of the essential details of the cleaning process.

Farm B milk also low grade. Since the milk from Farm B began coming into Geneva in November, 1918, 113 cans had been examined up to June 1, 1919, and of this number 45 graded as excellent, 18 as good, 37 as medium, and 13 as poor. As illustrated in Chart XX these percentages compare very unfavorably with the average quality of the entire milk supply during the same time, or even with the average

CHART XX.— QUALITY OF MILK FROM FARM B AS COMPARED WITH THE QUALITY OF THE GENERAL MILK SUPPLY, NOVEMBER, 1918 TO JUNE, 1919.



quality of all the machine-drawn milk, while the hand-drawn milk was decidedly superior.

Many sources of trouble found. An eight-day visit was made to Farm B in order to study the conditions prevailing there, and while a general inspection of the dairy barn and equipment showed them to be of standard construction (Fig.43), they were poorly kept. Manure had been allowed to accumulate on the cement platform behind the stanchions making it difficult to keep the milker pails and other utensils clean. While there was a good supply of running water (temperature 62° F.) in the barn and milk room, no provision was made for hot water except that it could always be obtained at the house nearby. A large concrete vat in the milk room was filled with water at each milking, and the cans set in it up to their necks. Later a drain was provided so that a stream

of water was constantly supplied. The cows were kept fairly clean, but little attention was paid to the condition of the udders when the teat-cups were put on and they were often dirty. The sterilizing solution used for the teat-cups and tubes was kept in a twenty-five gallon crock (Fig. 42), and altho it was mechanically clean, the solution contained no hypochlorite and insufficient salt, so that it was not effective as a sterilizer.

The vacuum pipe line contained a few drops of moisture after each milking, and a milky spray drained out of the vacuum tank trap and the compressed air tank when the stop cocks were opened after milking. Three units of a Sharples machine had been used on this farm for some time. Altho the dairyman had supposedly cleaned the milking machines the day before the investigation started, a casual examination showed them to be dirty. It was found that the nipples were practically never removed from the bottom of the teat-cups and that the short milk tubes were scarcely ever taken off the cups, the cups and tubes simply being put in warm water, a brush run thru them a few times, and then rinsed in hot water. A coating of fat and dried milk was left on the inflations and in the tubes, worn inflations were not removed promptly, and much dried milk was found on the strainers in the check valve chamber, on the valve seats, and on the valves themselves. After the morning milking the machine pails and large milk cans were rinsed out with about a kettleful of hot water and turned upside down to dry, while at night the pails and tubes were simply rinsed out by sucking a pail of cold water thru them. When the tubes were placed in the sterilizing solution the caps were left on the milk claws, thus imprisoning air in the tubes and preventing the solution from acting upon all the inside surface of the tubes.

Proper cleaning improved the quality of the milk.

Previous to the third milking after the investigation began the teat-cups were completely taken apart and all the metal and rubber parts of the machines were thoroly cleaned with hot alkali water and rinsed with clear hot water, while the machine pails, strippings pails, and large milk cans were scalded and dried. The rubber parts were also soaked for about an hour in a strong hypochlorite solution. After the evening milking the tubes and pails were washed by drawing thru them, successively, a pail of cold water, a pail of hot soda water, and a pail of clear hot water, while the cups and tubes (with the screw caps removed) were placed in a brine solution to which had been added a stock solution of hypochlorite. Excellent results were secured under these conditions until the third milking when one can of milk graded as excellent and two cans as good.

Milk insufficiently cooled. Altho the usual precautions had been taken previous to this third milking and an aerator had been added to the equipment already in use, it was found that the running water did not cool the milk below 64° F., so that in the case of the evening milk, which stood for about sixteen hours before delivery, any organisms present in the milk had ample opportunity to multiply. At the next milking a change in the water supply was made which resulted in cooling the milk below 60° F., and from that time to the end of the investigation all the milk graded as excellent.

The final results show that the trouble at this farm was caused by failure to clean the machine properly combined with inadequate facilities for cooling.

Good milk produced on Farm C. In contrast to the farms described above, the history of Farm C is briefly reviewed as the dairyman had adapted the Station methods for cleaning milking machines to his own conditions so successfully that he had maintained an almost perfect record for producing milk with a low germ content. This record also corresponded with the high record maintained by Farmer C when he practised hand milking. The dairy barn, altho not strictly modern (Fig. 44), was kept reasonably clean and had a plentiful supply of light and air. Since the cows frequently came thru a muddy yard to get to the barn, their udders were carefully washed with warm water.

A double unit Empire machine was used on this farm and of the 274 cans of milk examined, 266 graded as excellent or good, 7 as medium, and one as poor. All utensils were thoroly scalded after each milking and everything that in any way came in contact with the milk was kept scrupulously clean, but the cups and tubes were never taken apart for a thoro overhauling oftener than once a week. The cups and tubes were kept in a strong chloride of lime solution (Fig. 45) except in the winter when brine was added to keep the solution from freezing.

During the summer of 1919 trouble was experienced in maintaining the excellent record made up to that time, and a microscopic examination of the milk showed that a yeast was commonly present. The dairyman was instructed to add brine to the sterilizing solution and since then his milk has graded as excellent or good, 32 cans excellent and 2 good.

Reasons for Farmer C's success. The important factors which contribute to the excellent record made on Farm C are as follows: (1) All the utensils with which the milk comes in contact are kept very clean, and as a rule, the dairyman and his wife care for the dairy themselves, not leaving it to incompetent or indifferent hired help. (2) The sterilizing solution is always sweet and clean, and in this connection it is

pointed out that it does not matter so much where the solution is kept as how it is kept. On Farm C the solution crock is kept in the dairy barn (Fig. 44). (3) The cows are always kept clean. (4) The dairyman himself is clean. (5) The barn is kept in good condition. (6) The milk is adequately cooled. Taken together these factors have resulted in the establishment of an excellent record which is proof that, with proper care, and attention, milk of good quality can be produced with a milking machine under practical farm conditions.

Conclusions. The chief conclusions to be drawn from the observations made on the three farms are as follows:

(1). The methods of cleaning are more important than the type of milking machine in determining the germ content of the milk.

(2). The essential requirements for the successful care of the milking machine are plenty of hot water, a good washing compound, a rack for drying the utensils, a good sterilizing solution in a large crock, and a willingness to use care twice a day for 365 days in the year.

(3). The neglect of any one of several important details in the cleaning process may make the difference between success and failure, while if attention is given to the details of the cleaning process, no trouble will be experienced from the contamination of the milk by the milking machine.

SOME OBSERVATIONS ON SOIL FERTILITY AND CROP PRODUCTION*

J. D. LUCKETT

Object and scope of experiment. For several years this Station has been carrying on studies both under greenhouse conditions and in the field in an effort to ascertain the relative importance with regard to crop production of various factors affecting soil fertility.

The greenhouse work included observations on the following points:

1. The unlike feeding capacity of different crops.
2. The influence of fineness of division upon the availability of ground rock phosphate (floats).
3. The fertilizing value of an iron ore waste.
4. The minimum amounts of available phosphoric acid and potash required by different crops to insure maximum growth.
5. The influence of fertilizers upon the productiveness of several types of soil.
6. The influence of fertilizers and of plant growth upon the soluble materials of different soils.

The field work embraced observations on the relative value of commercial fertilizers and manure upon corn, oats, wheat, and timothy or clover grown in a four-year rotation. The experiment extended thru four rotations. The points concerning which, more or less definite conclusions were drawn are as follows:

1. The relative production of crops with farm manure, complete commercial fertilizer, and acid phosphate supplemented with sodium nitrate.

* Reprint of Popular Bulletin No. 473, March, 1920. The Complete Bulletin is reprinted on p. 27. This is a brief review of Bulletins Nos. 358, 360, 424, 465, and 473.

2. A comparison of farm manure and complete commercial fertilizer.
3. Clover as a factor in fertility.
4. The relative profitableness of the different methods of treatment.

Laboratory studies were also made to determine the value of chemical soil analysis as a means of measuring fertility.

Comparison of different phosphates. In Bulletin No. 358 experiments are described in which boxes of rather poor sandy soil were treated in the greenhouse with equal amounts of available forms of necessary plant food constituents other than phosphoric acid. The latter was then supplied either as acid phosphate, finely ground Florida rock phosphate, Thomas slag, dehydrated Redonda phosphate, or bone-meal, the assumption being that since the form of phosphoric acid was the only variable factor, any differences in crop production from the several sets of boxes might reasonably be attributed to the comparative availability of the phosphatic materials. Altogether the growth with the different phosphates has been recorded for three crops of vetch, cabbage, and rape; for two crops of oats, barley, and tomatoes; and for one crop each of rye, beans, millet, clover, and peas.

Different plants have unlike feeding capacities. The striking and important fact brought out by the experiments was the unlike capacity of different kinds of plants to utilize a given source of plant food, or, in other words, the unlike adaptability of a given soil environment to the needs of different species of plants. The results secured showed beyond doubt that under the conditions of the experiment the availability of a phosphate is quite as much a matter of the kind of crop as of the form of phosphate employed. Barley, millet, and oats made excellent growth with acid phosphate, while they acquired insignificant amounts of phosphoric acid and made little growth with rock phosphate. On the other hand, cabbage and rape in some cases produced as much dry substance with rock phosphate as with acid phosphate, and in no instance was the amount much less than three-fourths as large. These plants also absorbed phosphoric acid from rock phosphate in fairly large amounts, altho not as much in proportion to the growth of dry substance as from acid phosphate.

Thomas slag and Redonda phosphate seemed to be quite available to all the crops altho, with one exception, the growth was less for all crops and in all the experiments than that with acid phosphate.

Roots react differently upon soil compounds. Whether plants possess, with different degrees of intensity, what may be called "feeding power," or whether it is a question of securing for each species a "sympathetic" soil environment, is regarded as fundamental to a reasonable understanding of plant nutrition. Since it is quite evident that plants possess more or less selective powers in taking up available food material with which the roots come in contact, it is thought possible

that there may be differences in their reaction upon a given compound in preparing for its absorption. This leads to the conclusion that the roots of the various species of plants do not react alike upon soil compounds, altho this should not be regarded as condemning the use of insoluble phosphates under all conditions.

Fineness of division affects availability of raw rock phosphate.

Another series of box experiments were carried on in which all the necessary forms of plant food were supplied, except to the checks, the phosphoric acid being provided either as acid phosphate, Florida raw rock phosphate, or bone-meal. The rock phosphate varied in fineness from material that would pass thru a sieve with sixty meshes to the inch to so-called floats. The bone-meal also varied in fineness of division from that which passed thru a 60-mesh sieve to "fine" material. The crops tested included barley, peas, and rape.

The results secured with raw rock phosphate showed that the availability of the material was influenced by the fineness of division, the amount of P_2O_5 taken up by all three crops increasing quite uniformly with the degree of fineness. In the case of the bone-meal the availability was little affected by a fine division of the material.

The use of finely ground raw rock phosphate or bone-meal had little influence upon the growth of dry substance in the different crops, the plants seeming to secure sufficient phosphoric acid from even the coarsest materials to meet the needs for maximum growth under the conditions of the experiment. The amount of phosphoric acid assimilated from the acid phosphate was markedly greater than that taken up from the raw rock phosphate even tho the production of dry substance was little, if any, larger.

Iron ore waste of little fertilizing value.

A by-product, known as iron ore waste and supposed to contain a considerable amount of phosphoric acid, was compared with other phosphatic materials in box experiments with barley. The results showed that the phosphoric acid in the by-product had little availability. Chemical tests also demonstrated that the waste material contained relatively little available phosphoric acid when compared with the other phosphorus carriers used.

The food requirements of plants.

A question frequently asked by farmers is how much nitrogen, phosphoric acid, or potash is removed from the soil by a particular crop, the impression being that a plant utilizes during growth only what it actually requires for its best development, and that a knowledge of the composition of the plant will indicate what should be supplied either in the soil or in a fertilizer. Experiments described in Bulletin No. 360, conducted with barley, peas, tomatoes, tobacco, buckwheat, rape, and turnips in the Station greenhouse during three seasons show that such an assumption is hardly justified.

Effect of varying the amount of P_2O_5 and K_2O. Boxes were prepared in which all the needed plant food elements were supplied in abundance except phosphoric acid which was added in increasing quantities to the several boxes. In a second lot of boxes all the necessary ingredients were provided except potash which was also added in progressive quantities. An artificial "soil" was used which was much less complex than natural soil, and the temperature and the water supply so regulated as to meet the need of the plants as far as possible. The growth of the plants was as satisfactory, in most cases, as would have been the case under field conditions, while the production of dry substance in the barley during two of the three seasons was beyond what could be expected in a farm crop.

The results secured were strikingly uniform and clearly demonstrated that under the conditions of the experiment no fixed relation was maintained between the production of dry substance in the crop and the amounts of phosphorus and potassium utilized. By continuing the experiments thru several seasons it was hoped that some quite definite relation might be found between the phosphorus and potassium requirements of the different crops and the dry substance produced. However, the data obtained do not permit the establishment of such a relation, altho it is thought possible that other factors may have obscured the limitations of the plant food supply.

Plants may use more P_2O_5 and K_2O than they need. Up to a rather indefinite point in the development of the various crops studied, the production of dry substance in the plant increased, in most cases, with an increase in the supply of either phosphoric acid or potash. Beyond this point, however, the utilization of both phosphorus and potassium increased without any consistent or well defined corresponding increase in plant dry substance. In fact, in practically all cases there was a quite regular increase in the proportion of phosphorus and potassium in the plants of the several crops studied which corresponded to the supply of these ingredients in the soil.

Crop analyses misleading. The results secured strongly emphasize the fact that the amounts of soil compounds used by farm crops are materially influenced by chemical conditions surrounding the roots. In view of this fact it is not necessarily true that what a given crop may contain of certain elements is to be regarded as a measure of what must be supplied to meet the needs of that crop for maximum growth under existing conditions. Fertilizer formulæ based on crop analyses are, therefore, only *approximations* of the real needs of the crop, and it seems more than probable that, in field practice, a liberal supply of readily available plant food materials increases the amounts of these materials utilized by the crop out of proportion to the production of dry substance.

Fertilizer studies with different soils. In Bulletin No. 473 greenhouse experiments conducted during two seasons are described in which muck, leaf mold, stable manure, and complete commercial fertilizers were applied in varying amounts to nine soils taken from different localities in the State, each soil receiving the same treatment. In addition commercial fertilizers were applied alone and in different combinations, and in unlike quantities to two soils, one a fertile soil from the Station farm, and the other a poor soil from the Pine Plains region. The boxes were seeded to barley which was allowed to mature, the growth being very satisfactory.

Commercial fertilizers more effective than peat or manure. The use of muck or leaf mold alone had very little influence on the growth of the barley plant on the nine soils. In the case of stable manure the production of barley dry substance was much less than that secured with commercial fertilizers carrying the same amounts of nitrogen, phosphoric acid, and potash. Without exception the growth of the barley plant increased with an increase in the amount of fertilizer applied, altho not in proportion to the amount used. The increase in production accompanying a doubling of the amount of fertilizer applied was greater than that following any further increase of fertilizer. Lime used in connection with manure had a very irregular effect on the yield, a marked increase following its use on four of the soils, a manifest advantage from its use on three soils, and an apparent injury on two soils.

Nitrogen gives the best results. Where commercial fertilizers were applied alone and in different combinations, nitrate of soda exerted the greatest influence. Neither phosphoric acid nor potash when used alone had any marked effect on crop yield. The combination of nitrogen and phosphoric acid resulted in a somewhat larger growth of barley than nitrogen alone, altho the increase from the addition of the phosphorus was rather insignificant when compared with that following the application of nitrogen alone. The combination of nitrogen and potash gave practically the same production of dry substance as nitrogen alone, while a combination of nitrogen with both phosphoric acid and potash gave about the same yield as nitrogen and phosphoric acid together. Either alone or in combination potash seemed to have little influence on the growth of the barley plant on the two soils used in the experiment.

Greenhouse conditions different from field conditions. It has often been observed that vegetation experiments with soils in the greenhouse give results quite different from those obtained with the same soils under field conditions. In these experiments the Pine Plains soil, which is properly regarded as an inferior type for general cropping, produced twice as much dry substance on the boxes receiving no fertilizer as did the fertile Station soil, while the application of fertilizers caused as large

production on the Pine Plains soil as on the Station soil. Moreover, the application of nitrogen alone gave a marked increase of crop on both soils, a result which would hardly be secured on these soils under ordinary field culture. The explanation of these differences is difficult, but it may be suggested that the constant warmth and abundant moisture to which the greenhouse soil was subjected would favor the process of solution and thus make possible the maximum use of the soil ingredients. In addition to these favorable conditions of growth, the plants were protected from insect and fungus pests, and were thus enabled to exert their maximum vigor in securing materials for growth.

Whatever may be the explanation it is obvious that so far as the farmer is able to duplicate greenhouse conditions in the field, just so far is he promoting luxuriant plant growth. Furthermore, the data secured in these experiments are suggestive as to the use of fertilizers in forcing plants under glass.

Fertilizers and plant growth affect soil solutions.

Past studies have shown that when nitrates and soluble compounds of phosphorus and potassium are mixed with the soil, the nitrogen remains in a soluble condition, the phosphorus almost wholly enters into water insoluble forms, and the potassium undergoes changes which render it available only thru continued leaching. The vegetation experiments with the nine soils mentioned above offered an opportunity to study the effect of the addition of fertilizers upon the soluble material of the soil. Therefore, after the second crop of barley was harvested soil samples were taken and the amounts of nitrogen, phosphorus, and potassium brought into solution were determined.

In order to secure data on the persistence of the soluble compounds in the soil following the application of fertilizers, and, also, to compare the proportion of soluble material in soil on which no crop had been grown with that from the soil on which two crops of barley were grown, fertilizers were applied to boxes containing the nine soils but no crop was grown on the boxes. One box of each soil was neither fertilized nor cropped. Soil samples were selected from these boxes on seven different dates and a determination made of the water soluble material.

Studies with one soil.

A more detailed study of the effect of fertilizers and of plant growth on soil solubles was made with soil from the Station farm. Sets of boxes were treated with varying amounts of a complete fertilizer and certain of the boxes seeded to barley. The boxes that were not seeded were kept free of weeds and were subjected to the same moisture conditions as those in which barley was growing. One set of boxes was not fertilized, part of the boxes being cropped and part uncropped. The barley was harvested at four different periods, and at the same time samples of soil were taken from the

cropped boxes and also from the uncropped boxes and determinations made of the water soluble material.

Fertilizers increase the proportion of soil solubles.

As was to have been expected from results secured in other investigations, the addition of soluble fertilizer compounds to the various soils materially increased the proportion of soluble matter in the soils, the increase being least with phosphorus and greatest with nitrogen. In general, the increased solubilities persisted without material change in the uncropped boxes, altho the results were not entirely uniform.

The conditions under which these observations were made were not similar to what might exist in the field, especially at a time of considerable rainfall. The fertilizers were mixed with thirty pounds of soil having a depth of about six inches, while in ordinary cultivation the incorporation of fertilizers in the soil probably does not reach this depth. In case of rains, however, there would be movements of water in the soil carrying the soluble compounds to lower levels which might materially diminish the proportion of solubles, especially with the phosphorous and potassium. Without rain, the field conditions might not be greatly different from those existing in the greenhouse.

Crop growth affects soil solubles.

The effect of the growth of crops upon the soluble material of the soil was found to be quite marked. The data secured from the nine soils mentioned above not only gave evidence of the large increase in solubles, due to the application of fertilizers, but also show a great reduction in the water soluble compounds when two crops of barley were grown to maturity. In the case of the Station soil where the barley, which was seeded on January 24, was harvested at different stages of maturity, the amount of dry substance in the crop harvested March 18 varied from 15.4 to 18.8 grams per box, but notwithstanding this small growth a large proportion of the water soluble nitrogen and potassium had been utilized by the plants. On April 15, when the growth had increased considerably, a still further decrease in soil solubles had taken place. On May 10 with a much increased production of dry substance, and also on June 1, when the mature crop was harvested, the solubility of the soil ingredients remained practically unchanged.

The striking facts in this connection are that the plants utilize the soluble materials, and that the reduction of these materials in the soil was quite rapid even before the plants attained any considerable growth. In the later stages of plant growth the soil solubles appeared to be maintained somewhat on a level which was not greatly different, with the exception of the phosphorus, from the level maintained in the boxes receiving no fertilizer. This agrees with former conclusions that there is a proportion of water soluble materials maintained in

the soil at a nearly constant level, irrespective of the growth of vegetation sustained by the soil.

Immediately available plant food essential.

The data secured in these studies appear to have a significant bearing on the importance of the solubility of the essential ingredients of fertilizers, especially in the production of quickly growing crops. Plants accumulate a large proportion of the needed nitrogen and ash constituents during their early stages of growth. In greenhouse culture and vegetable gardening, and for the production of such crops as cabbages, potatoes, and wheat, an adequate supply of immediately available food would seem to be essential to successful cropping.

Field experiments of limited value.

The problem of crop production is extremely complicated, many factors, physical, chemical, and biological, being closely related to soil fertility. Because of the complex nature of the soil, progress in the solution of soil problems has been slow and unsatisfactory. Laboratory investigations and observations upon the growing plant both in the greenhouse and in the field have contributed to our present knowledge of soil conditions. Laboratory and greenhouse investigations while of considerable importance in establishing fundamental truths do not form an adequate basis for recommendations for field practice. These limitations of perfectly controlled observations might lead one to expect conclusive evidence from field tests if it were not for the fact that it has not been possible, in most cases, to determine either the absolute or relative influence of the various factors affecting plant growth in the field.

The results of field experiments are determined by local conditions which may or may not be similar to the conditions of any other farm or region. A vast number of field experiments with fertilizers have been recorded in this country and elsewhere, but all the accumulated evidence has established only a few general principles which might serve as a safe guide to the individual farmer in regulating his practice. In other words, the maintenance of soil fertility is a local problem.

Plan of field experiments.

Field experiments with various crops grown in a four-year rotation and receiving different fertilizer and manurial treatments were begun at this Station in 1896, and the results, which are more fully recorded in Bulletin No. 465, have a bearing on the subject under discussion. The plan of the experiment is shown in the following diagram.

The area of the field selected for this work was twelve acres and was divided into eight plats with four feet between plats. The actual dimensions of the plats were 4 x 60 rods. The crops grown in the rotation were, in the order named, corn, oats, wheat, and clover or timothy as indicated in the diagram. The data cover the results

secured during four rotations. All the manure and fertilizer applications were made on the corn and wheat, nothing being added to the oats and grass. The yield of the plats was measured in two ways, first by the weights of the crops as harvested, and, second, by the amount of dry substance contained in the crops. The latter measurement is thought to be the one deserving chief consideration as the dry substance is a fundamental measure of the production of a crop either for human food or for feed.

No. of plat.	Arrangement and General Treatment of the Plats.
1.	Farm manure..Clover in rotation.
2.	No fertilizer..Clover in rotation.
3.	Partial fertilizer, P_2O_5 and minimum N...............Clover in rotation.
4.	Farm manure..Timothy in rotation.
5.	Complete fertilizer, P_2O_5, K_2O, and maximum N.......Clover in rotation.
6.	No fertilizer..Timothy in rotation.
7.	Partial fertilizer, P_2O_5 and minimum N...............Timothy in rotation.
8.	Complete fertilizer, P_2O_5, K_2O, and maximum N.......Timothy in rotation.

Effect of different treatments on yield.

A study of the data showing the yield of dry substance in the various crops grown under the different treatments reveals a marked variation in production. The plats receiving farm manure and those which received complete commercial fertilizer produced about 56 per cent more dry matter than the unfertilized plats. Applications of acid phosphate and small amounts of nitrogen with no potash produced about 33 per cent more than the untreated plats. In connection with these figures, it should be

borne in mind that the crops were grown in a system of rapid rotation, and that in the case of four of the plats excellent crops of clover were grown in each rotation so that a good clover sod was turned under together with more or less second growth in certain years. Also, in 1910 all the plats received one ton per acre of burned lime, previously slaked.

The results secured in these tests offer further evidence to dispose of the doctrine, somewhat prevalent at one time, that commercial fertilizers were chiefly palliative in character, and that with proper rotation and soil treatment a desirable level of crop production could be maintained. Another interesting and important fact brought out by the experiment is the relative productivity of the several crops employed. The data show that the growth of dry substance in corn is more than twice that in either oats or wheat (including the yield of barley as part of the wheat), or even of hay, notwithstanding the fact that the crops of cereals and hay were considered very satisfactory. This is a fact to which the dairy farmer should give careful consideration in planning to secure the largest amount possible of available food for milk production.

Farm yard manure vs. commercial fertilizer.

A question which is much discussed, especially in the Eastern states, is the maintenance of soil fertility by the use of commercial fertilizers, and the results secured in the field experiments may serve as a partial answer. The total yields of dry substance obtained from all the crops under the two methods of treatment for the entire period of the experiment are given in Table I.

TABLE I.— COMPARATIVE YIELD OF DRY SUBSTANCE WITH FARM MANURE AND COMMERCIAL FERTILIZER.

TREATMENT.	TOTAL YIELD.	
	Clover in rotation.	Timothy in rotation.
	Lbs.	*Lbs.*
Farm manure	118,367.8	109,559.8
Complete fertilizer	113,917.2	106,297.9
Difference in favor of manure	4,450.6	3,261.9

Accepting the figures on their face value, the superiority of farm manure must be conceded, altho the difference in results from the two methods of treatment is not large. Attention should be called to the fact that while the amount of manure applied did not exceed

what is regarded as a liberal quantity (about 10 tons per acre applied twice in each rotation), the quantities of the valuable plant food elements present in the manure were doubtless much above those applied in the complete commercial fertilizer. In fact, chemical analyses of the manure showed that, on the average, 131 lbs. of nitrogen, 120 lbs. of phosphoric acid, 202 lbs. of potash, and 183 lbs. of lime were applied to each plat every second year, amounts much larger than those supplied in the usual application of commercial fertilizer.

Another factor to be considered is that the plats were allowed in grass but one year, so that the timothy was placed at quite a disadvantage because of the well known fact that a timothy sod should be maintained more than one year in order to get maximum results. Subtracting from the total amounts of dry substance produced under the two systems the dry substance contained in the clover and timothy hay, a comparison can be made of the influence of farm manure and a complete commercial fertilizer upon cereal crop production as indicated in Table II.

TABLE II.— FARM MANURE VS. COMMERCIAL FERTILIZER FOR GRAIN CROPS.

TREATMENT.	TOTAL YIELD OF DRY SUBSTANCE.	
	Clover in rotation.	Timothy in rotation.
	Lbs.	*Lbs.*
Farm manure	91,306.0	84,348.4
Complete fertilizer	90,194.4	89,944.8
Gain or loss with manure	+1,111.6	—5,596.4

The farm manure appears to have produced somewhat better results on the clover plats than the fertilizer, while on the timothy plats the yield of the grain crops with manure was markedly inferior to that with commercial fertilizer.

As this experiment covers a period of seventeen years these results have some weight in considering the efficiency of the two methods of maintaining fertility.

Clover as a factor in maintaining fertility.

Investigation has shown conclusively that under certain conditions leguminous plants are able to acquire nitrogen from the atmosphere, and because of this, clover has been regarded as a very important factor in maintaining soil fertility. One of the objects of the field experiments under discussion was to study the influence of clover upon fertility. A fine clover sod has been turned under on four of the plats during each rotation and it was expected

that the advantage of the clover would be particularly marked on the check plats and on the plats receiving very limited amounts of nitrogen in the commercial fertilizer. The relative yields of all the crops grown in rotation with both clover and timothy are shown in Table III, together with the differences in yield of all the crops and of the cereal crops due to the clover.

TABLE III.— EFFECT OF CLOVER ON CROPS IN ROTATION.

FERTILIZER TREATMENTS.	YIELD OF DRY SUBSTANCE.		DIFFERENCES WITH CLOVER.	
	Clover in rotation.	Timothy in rotation.	Excess of all crops.	Excess of cereal crops.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Farm manure	118,367.8	109,559.8	8,808.0	6,957.6
Complete fertilizer	111,917.2	106,297.9	5,619.3	451.5
Partial fertilizer	100,091.9	88,932.4	11,159.5	4,391.4
No fertilizer	72,853.8	70,619.9	2,233.9	—1,934.9
Total differences	....	....	27,820.7	9,865.6

These figures seem to justify the claims for the value of clover in rotation, but in view of the fact that the yield of hay on the timothy plats was not so large as it would have been had the rotation continued for another year, it is probably fairer to judge the influence of the clover by its effect upon the yield of the cereals than upon the yield of all crops. This point is brought out in the last column of Table III where the yields of hay have been subtracted. The increased yield of the clover plats is greatly reduced, and on the check plats the larger yield was secured on the timothy plat.

Observations on the influence of clover in maintaining crop production on the untreated checks offers an even severer test of its value. The figures given in Table IV show the yields for all crops in the different rotations.

TABLE IV.— TOTAL YIELDS OF DRY SUBSTANCE IN 17 YEARS WITHOUT FERTILIZER OR MANURE.

ROTATIONS, 4 YEARS EACH.	CLOVER IN ROTATION.	TIMOTH IN ROTATION.
	Lbs.	*Lbs.*
First	16,947.0	17,703.8
Second	17,873.9	12,665.3
Third	14,458.6	14,957.9
Fourth	14,760.7	16,092.3

It will be seen that after the first rotation the yield was maintained at practically the same level with the exception of the yields from the timothy plat in the second rotation. The yield in the fourth rotation was practically as large as that in any previous rotation except the first. While it is well known that the soil on the Station farm has large potential fertility, it is rather surprising that without the use of any fertilizer or manure no decrease in productivity was observed during the last twelve years of cropping. The outstanding fact in this connection is that on the timothy plats crop production was maintained as efficiently as on the clover plats.

The business side of the experiment. It is often customary in discussing field experiments with fertilizers to measure the results secured from the different methods of treatment by the market value of the increase in crop production following the use of the fertilizers. If expressed only in terms of market values, such experiments are simply tests of business methods and the final figures show the profit or loss from a given system in a certain locality, while entirely different results might be secured another year or in another community. Conclusions based on such deductions do not express anything fundamental. It is possible, however, to study results as expressed in market values so as to secure a comparison of relative profits under a given set of conditions but the figures obtained may have very limited application.

TABLE V.— ESTIMATED PRICES OF FERTILIZERS AND CROPS.

MATERIAL.	PRICES PER TON DURING EXPERIMENT.	PRESENT PRICES PER TON.
FERTILIZERS.		
Acid phosphate	$14.00	$26.00
Dried blood, 10% N	40.00	80.00
Nitrate of soda, 15% N	54.00	90.00
Muriate of potash, 50%	45.00	225.00
Stable manure	2.00	4.00
CROPS.		
Silage	3.00	6.00
Hay	10.00	20.00
Oat straw	8.00	12.00
Oat grain	.40*	.70*
Wheat straw	6.00	12.00
Wheat grain	1.00*	2.50*
Barley straw	5.00	10.00
Barley grain	1.00*	1.00*

* Price per bushel.

Since the field experiments were begun, there has been a very great change in the market prices of both fertilizers and crops. In Table V is stated, as nearly as can be estimated, the prices of the fertilizing materials employed and of the crops produced during most of the time covered by the experiment, together with prices for 1919.

In the complete bulletin tabulated data are also presented to show the increase in crop production from the various methods of treatment, the cost of the fertilizer, and the value of the crop. Based on these figures there has been calculated the increase of crop values over the cost of the fertilizers, together with the cost of one pound of increase of both total and dry substance produced on all the plats. The cheapest increase of production was obtained from the use of acid phosphate supplemented with a small amount of nitrate of soda, the additional crop yield following this treatment costing much less than the sum for which it could have been purchased either at former or present prices. Whether or not a profitable increase in yield could be secured from the use of a complete fertilizer with a maximum amount of nitrogen would depend upon circumstances as it is difficult to draw conclusions regarding business results which are generally applicable. The returns from the use of farm manure indicate that this material was worth approximately the prices stated.

Measuring soil fertility.

In Bulletin No. 424 investigations, conducted with the nine soils employed in the greenhouse experiments noted above, are described in which observations were made on various methods of chemical analysis for determining the crop-producing capacity of different soils. The methods of examination employed included (1) a complete analysis of the soils whereby the entire amount of each ingredient present in the soil was determined; (2) determination of the material soluble in strong acid; (3) determination of the materials dissolved by continued leaching for ten days with water, very weak acid, and somewhat stronger acid; and (4) determination of the soluble material obtained by shaking five hours with water, very weak acid, and the stronger acid. As already indicated these soils showed by vegetation tests that they possessed greatly unlike crop-producing capacities.

No satisfactory method yet developed.

To briefly summarize the detailed data given in the complete bulletin it may be stated that by no one method of chemical examination was there established any relation between the amounts of nitrogen, phosphoric acid, and potash, either total or soluble, and the crop-producing capacity of the soil. There did seem to be some relation between the total soluble matter in the soil and productiveness in that the two soils giving a very low yield of barley showed much less solubility than the others but this relation was not consistent. The general result of this investigation shows that we are

not yet in a position, thru laboratory methods so far devised, to measure the fertility of the soil.

Additional evidence regarding chemical soil analysis. The long-continued field experiments in cropping land under different treatments as described in Bulletin No. 465 offered an opportunity for making further observations on the value of chemical soil analysis as a means of measuring soil fertility. Samples of soil were taken from each plat when the experiment was begun and again after seventeen years cropping. A close study of the figures showing the percentages of nitrogen, and phosphorus and calcium oxides in the soil from the various plats reveals no relation of these percentages to the productivity of the plats at the end of the experiment, nor do the figures indicate any appreciable changes in the composition of the soils after seventeen years of greatly unlike treatment in the application of fertilizers and manure and in cropping.

Conclusions. Important points brought out by the experimental work reported in the bulletins under discussion may be summarized as follows:

1. The kind of crop affects the availability of a phosphate as much as the form of phosphate used.
2. The roots of different species of plants do not react alike upon soil compounds.
3. The availability of rock phosphate increases with the fineness of division.
4. The iron ore waste examined had little fertilizing value.
5. The composition of the plant is not a reliable guide to the fertilizer needs of the soil.
6. The use of commercial fertilizers resulted in a greater production of barley dry substance than that which followed the application of stable manure having the same amounts of nitrogen, phosphoric acid, and potash.
7. The growth of barley dry substance increased with an increase in the amount of fertilizer applied altho not in proportion to the amount used.
8. Lime as a supplement to manure had a very irregular effect on crop yield.
9. Nitrogen applied alone gave the best results both on the fertile Station soil and the poor Pine Plains soil.
10. The addition of phosphorus to nitrogen produced a small increase in yield.
11. Either alone or in combination potash appeared to affect the growth of the barley plant very little on the two soils.
12. Results secured with soils studied under greenhouse conditions differ from those obtained in the field, but the data accumulated in these experiments are suggestive as to the use of fertilizers in forcing plants under glass.

13. The addition of soluble fertilizers materially increased the proportion of soluble matter in the soil.

14. Growing plants utilize the soil solubles, and the reduction of these materials is quite rapid even before the plants attain any considerable growth.

15. An adequate supply of immediately available plant food is essential to successful cropping.

16. The application of commercial fertilizers and manure to crops grown in rotation resulted in a marked increase in yield over untreated checks.

17. The production of dry substance in corn was more than twice that in either oats, wheat, or hay.

18. Farm manure gave somewhat higher yields for all the crops grown in rotation than did a complete fertilizer, but based on the yield of the cereal crops alone farm manure gave only a small increase over a complete fertilizer for the clover rotation, while the fertilizer resulted in a marked increase over manure in the timothy rotation.

19. In the rotation experiments without fertilizers or manure, crop production was maintained as efficiently on the timothy plats as on the clover plats.

20. The use of acid phosphate, supplemented with a small amount of nitrate of soda, gave the cheapest crop increase secured in the field experiments.

21. It is not yet possible to measure accurately the fertility of the soil by chemical analysis.

SEED POTATOES IMPROVED BY CLOSE PLANTING *

J. D. LUCKETT

Opinion varies as to best spacing of potatoes

Lack of agreement on the part of New York potato growers, even in the same locality, as to what spacing gives the best results, would seem to indicate that they are guided more by personal experience and observation than by experimental evidence. The method of planting, whether in drills or check rows; the distance between plants in the row; the variety of potatoes grown; the fertility and cultural condition of the soil; the size of the seed-piece, all enter into consideration in determining the proper spacing of potatoes. In addition, a planting scheme adapted to certain seasonal conditions may be entirely unsuited to different conditions. The distance between rows has been found to vary from 30 to 39 inches, and the distance between plants in the row from 9 to 36 inches. It is evident, therefore, that many factors are involved which make the problem quite complicated.

Small and medium sized tubers desirable for seed

Under the planting conditions usually prevailing in Western New York, varieties of the Rural group of potatoes, such as Rural New Yorker No. 2, Sir Walter Raleigh, Enormous No. 9, etc., produce many tubers which are too large to be suitable for seed purposes. Believing that the small tubers are as productive, weight for weight, when used for seed as are the large tubers from the same plant, it was deemed worth while to study means for increasing the proportion of small and medium sized tubers. Consequently, experiments were planned to determine the feasibility of employing close spacing in the production of seed potatoes as a means of reducing the average size of the tubers without reducing the total net yield. It was thought, too, that

* Reprint of Popular Bulletin No. 474, May, 1920. The Complete Bulletin is reprinted on p. 281.

thru a better understanding of the effects of different spacings, information might be obtained leading to an improvement of the quality of potatoes for table use by increasing the production of medium sized potatoes.

The plan of the experiment

Field experiments were conducted at Geneva during five seasons (1914, 1915, 1917, 1918, and 1919) and comprised, chiefly, a comparison of 6- by 36-inch planting with 15- by 36-inch planting. The variety Sir Walter Raleigh was used the first four years and Enormous No. 9 the last year of the experiment. The soil was a heavy clay loam of medium fertility. The rows of thick and thin planting were alternated. At harvest the product of each row was sorted, according to weight, into four grades, viz.: (1) Under one ounce; (2) from one to two ounces; (3) from two to twelve ounces; and (4) over twelve ounces. The tubers in each grade were weighed and counted.

General results

Detailed information is given in the complete bulletin showing the results secured each year of the experiment while the data may be briefly summarized as follows: The total number of tubers over one ounce in weight produced during the different years of the experiment varied from 41,847 to 62,600 per acre for the 15-inch planting, and from 71,603 to 97,150 per acre for the 6-inch planting, and resulted in a difference in favor of thick planting, varying from 29,281 to 34,550 tubers per acre. Expressed in another way, these figures represent yields of tubers over one ounce in weight ranging from 144.5 to 340.8 bushels per acre for the 15-inch planting, and from 191.8 to 384.4 bushels per acre for the 6-inch planting. The difference in net yield (total yield minus seed) varied from 24.9 to 46.6 bushels per acre in favor of the 6-inch planting, with an average of 34.7 bushels per acre. More than one-half of this difference, 18.7 bushels, comprised tubers over two ounces in weight.

With regard to an increase in the production of small and medium size tubers with 6-inch planting, the average weight of tubers weighing more than two ounces suffered a reduction during the different seasons of from 10.5 to 22.8 per cent. For table use, the tubers from the thick planting were thought to be more desirable in size in the 1914 and 1919 crops than those from the thin planting, but in the other three years the potatoes from the thin planting were of a better size.

Effect of spacing on number of tubers

As in the case of the total yield, the yield of the three smaller grades of tubers was considerably larger with the 6-inch planting than with the 15-inch planting in every year of the experiment. However, the yield of the extra large tubers, when there were any, was always greatest with the thin planting. On a percentage basis, the average increase, due to thick planting,

in number of tubers in the smallest grade was 119.1 per cent; in the one-to-two ounce grade, 144.5 per cent; in the over-two-ounce grades, 44.3 per cent; and for the total yield of tubers of all grades, 67.2 per cent.

Thick planting tended to reduce the average number of tubers produced per plant, the amount of this reduction ranging from 28.3 per cent in the 1918 experiment to 37.8 per cent in the 1914 experiment.

Effect of spacing on quantity of tubers

The largest total yields for both spacings were obtained in 1914, and the smallest total yields in 1917; yet the differences in yield in favor of thick planting for these two years was practically the same and the smallest of the series, namely, 49.3 bushels per acre in 1914, and 50.2 bushels per acre in 1917. Likewise, in the 1918 and 1919 experiments, which gave quite different total yields, almost the same difference in favor of thick planting was obtained, namely, 60.1 bushels per acre in 1918, and 61 bushels in 1919. The best results with thick planting were secured in the 1915 experiment when the difference in total yield was 83.2 bushels per acre. For all the experiments, the average increase in yield in favor of thick planting amounted to 28.9 per cent.

In a comparison of the percentage of increase in the number of tubers with the percentage of increase in the quantity of tubers, it was found that the latter was usually the higher in the two smaller grades of tubers, but considerably the lower in the marketable grade and in the total yield of all grades.

The average yield of tubers produced per plant in the 6-inch rows in 1914 was less than half that produced per plant in the 15-inch rows, while in each of the other four years the yield was slightly more than half.

Effect of spacing on size of tubers

The reduction in the average size of the tubers which resulted from thick planting enhanced the value of the crop for seed purposes, but its effect on the quality of the tubers for table use was less apparent. Just what size of potato is desirable for the table is largely a matter of personal opinion. In these experiments it was decided that in a lot of tubers varying from two to twelve ounces the average weight should be about 4.25 ounces to be most desirable for general family use where some of the potatoes were to be boiled, some baked, and some mashed. Based on this standard, the crop from the thin planting was superior to that from the thick planting in three years out of the five.

Of the total number of tubers produced in the 6-inch planting during the five years of the experiment, 64.1 per cent attained a weight of two ounces or more, while in the 15-inch planting 73.9 per cent weighed two ounces or over.

Effect of spacing on net yield

Two things must be taken into consideration with regard to close spacing: First, 6-inch planting requires two and one-half times the amount of seed necessary for 15-inch planting; and second, allowance must be made for the difference in the value of potatoes in the spring and in the fall.

As stated earlier, the average net difference in favor of thick planting for the five years was 34.7 bushels per acre, 18.7 bushels of which consisted of tubers weighing more than two ounces each, and the remainder of tubers weighing between one and two ounces.

Conclusions

While no attempt has been made to draw definite conclusions from the data as to the relative number, quantity, or size of tubers to be expected from 6-inch and 15-inch plantings, certain general recommendations may be made as follows:

1. In the production of seed potatoes of varieties of the Rural group, planting in this State should be considerably closer than 15 by 36 inches as the net yield of the crop is thereby increased and tubers of a more desirable size obtained.

2. Seed potatoes designed for home use may be planted as close in the row as is consistent with roguing, altho it is probably impracticable to rogue properly plants set as close as six inches.

3. A crop to be sold either for seed or for table use may require somewhat thinner spacing in order to avoid the production of a large number of small tubers.

4. Potatoes grown on rich garden soil for table use may be planted as close as 6 by 30 inches to good advantage.

THE NEW YORK SEED LAW AND SEED TESTING *

M. T. MUNN

THE NEW YORK SEED LAW

Farm seeds, the most variable, and, weight for weight, the most expensive material the farmer has to buy, can be purchased on and after July 1, 1920, with a complete tag or label attached to each sack, bag, or container showing the purity, germination, amount of weed seeds present, and the presence or absence of certain noxious weed seeds.

After considerable agitation New York has secured finally a law designed to protect the purchaser of seeds by giving him full information regarding the quality of the contemplated purchase; and, also, to protect the honest, legitimate dealer or seedsman against the practices of dishonest and irresponsible ones.

The New York "seed law," which became effective July 1, 1920, is primarily a labeling law in contradistinction to a grading law when grades are required. A copy of the law may be had upon application to the Commissioner of Agriculture, Albany, N. Y.

THE MAIN FEATURE OF THE LAW

The law requires the labeling of all agricultural seeds which are sold, offered, or exposed for sale, within the State of New York, for seeding purposes within the State either in bulk, packages, bags, or other containers of 10 pounds or more with the exception of special mixtures, such as lawn mixtures, when 8 ounces is the minimum limit of weight.

KINDS OF SEEDS TO BE LABELED

The term "agricultural seeds," as defined in the law, includes practically every kind of seed planted upon New York farms. The following are designated as "agricultural seeds" and are subject to

* Reprint of abridged edition of Bulletin No. 476, June, 1920. The Complete Bulletin is reprinted on p. 311.

all the provisions of the seed law when sold for seeding purposes: Canada bluegrass, Kentucky bluegrass, orchard grass, redtop, timothy, brome grass, fescues, millets, tall meadow oat grass, Italian rye grass, kafir corn, perennial rye grass, sorghum, sudan grass, and other grasses; alfalfa, alsike clover, crimson clover, red clover, white clover, sweet clover, vetches, rape, and flax; and buckwheat, barley, corn, oats, rye, wheat, and other cereals.

SEED MIXTURES

All mixtures of alsike clover and timothy, alsike and white clover, redtop and timothy, and alsike and red clover in lots of 10 pounds or more must be fully and completely labeled in the same manner as unmixed agricultural seeds.

Special mixtures of agricultural seeds, that is, mixtures which usually carry a number of different kinds of seeds, when in lots of 8 ounces or more must also be fully labeled except that the law does not require a statement of the germination percentage in the case of the special mixtures. However, the percentage of inert matter must be given.

In the case of both mixtures and special mixtures as defined above the law requires a statement to the effect that "such seed is a mixture;" and also, "the name and approximate percentage by weight of each kind of agricultural seed present" in excess of 5 per cent or more of the total mixture.

THE LABEL

The law requires each lot of seed to carry a statement, tag, or label giving the following information:

1. **The commonly accepted name of such seed.**— For example, Dwarf Essex rape, Canada bluegrass, and Kentucky bluegrass must be called such on the label since these are their commonly accepted names, and not simply rape and bluegrass. The kind of seed must, therefore, be indicated. Variety and sub-variety names are not required, but if named on the label, as the vendor may elect, they must be the true variety name, otherwise, the seed would be misbranded or falsely labeled. As an illustration, if a label reads "yellow sweet clover" the seed must be of that variety and not of another variety such as white sweet clover.

2. The approximate percentage, by weight, of purity.— A statement of purity shows the amount of crop seeds of the kind which the label indicates as compared with the amount of weed seeds and inert matter present and must be expressed in terms of percentage by weight. Purity, then, is one of the important factors which determines quality and consequently price.

3. The percentage of weed seeds.— The total amount of weed seeds, whether noxious, troublesome, or otherwise, expressed in terms of percentage, must be stated on the tag or label. The term "weed seeds" as defined in the law does not include the seeds of field crops which are listed in the law as "agricultural seeds." Seeds of crop plants of agricultural value, which occur incidentally or thru natural infestation by ripening at the same time and being harvested with the crop and which occur in any sample of a given kind of seed, are known to seed analysts and the seed trade as "other crop seeds," "foreign seeds," "seeds of extraneous crop plants," and "other crop seeds of agricultural value." A distinction should be clearly made, therefore, between the accidental commercial seeds and weed seeds in a sample. The seed law does not require that the percentage of "other crop seeds" or of accidental commercial seeds be stated, nevertheless, it should be clearly understood that seed testing stations and laboratories in making purity tests of a lot of seed, do not, as a rule, separate and express in separate percentages the accidental commercial seeds and the weed seeds. It is often of great importance that the percentages of other crop seeds be given in distinction from weed seeds since, in many cases, they are of equal or greater value than the agricultural seed in which they occur.

4. The name of each kind of the seeds of noxious weeds.— The name of each kind of noxious weed present must be stated on the label when it occurs, either singly or collectively, in excess of 1 seed in each 5 grams (about one-sixth of an ounce) of small seeds such as timothy, clover, and alfalfa; of 1 seed in each 25 grams (about six-sevenths of an ounce) of millet, rape, and seeds of like size; and of 1 seed in each 100 grams (about 3½ ounces) of oats, wheat, vetch, and seeds of like size. The law designates four kinds of weeds as noxious in this State, *viz.* quack grass, wild mustards, Canada thistle, and dodders.

The sale of seeds containing these noxious weed seeds is not prohibited, but it is required that the label or tag show if they

are present, in order that the purchaser may avoid buying seeds containing them.

5. **The percentage of germination together with the month and year when the test was made.**— With respect to germination, the law requires that two very important facts be stated on the tag or label on all lots of seeds except "special mixtures." First, the percentage of germination or the percentage of seeds which are alive or viable and which will sprout or germinate within the normal number of days must be indicated. This is highly essential in determining the quality and actual value of the seed for seeding purposes since dead seed is worthless for planting and is deceptive in determining the amount of seed to use. Second, the date, that is, the month and year, when the test was made must be given. This second item is essential since the vitality of seeds decreases with age, and the purchaser can readily determine from the tag or label whether sufficient time has elapsed to materially affect the viability of the seed under normal storage conditions.

6. **The full name and address of the vendor.**— The label must also give the full name and address of the person who sells, offers, or exposes for sale such seeds.

LABELING MIXTURES

Mixtures of alsike clover and timothy, alsike and white clover, redtop and timothy, and alsike and red clover, when in lots of 10 pounds or more, must carry a tag or label giving essentially the same information required for the unmixed or regular run of agricultural seeds except that the tag must state that such seed is a mixture, and must also give the approximate percentage by weight of each kind of crop seed present in excess of 5 per cent of the total mixture. Also, each kind of the above-defined noxious weed seeds present in excess of 1 in each 15 grams of the mixture must be named.

LABELING SPECIAL MIXTURES

Special mixtures of seeds, such as golf, pasture, meadow, and lawn mixtures when sold, offered, or exposed for sale as mixtures, in packages or other containers of 8 ounces or more, must carry for each lot a tag or label stating (1) that such seed is a mixture,

(2) the name of each kind of "agricultural seed" present in the proportion of 5 per cent or more of the total mixture, (3) the total percentage of weed seeds, (4) the percentage by weight of inert matter such as chaff, sticks, broken stems, sand, etc., (5) the name of each kind of noxious weed, as defined on page 536, present in excess of 1 seed in each 15 grams of the mixture, and (6) the full name and address of the vendor of such mixture.

FORM AND POSITION OF LABEL

The law does not require any particular form of statement, tag, or label except that it must convey definite information plainly written or printed in the English language as set forth therein, and must be placed on the exterior of the container. If the container is a bag of seed, the label should appear on the outside of the bag; if it is a barrel, bin, box, or package, on the outside of the container. The intent of the law is to place the information given on the label concerning the quality of the seed in such a form and position that it is accessible to the purchaser so that he may determine at a glance, if he will, what the seed is and, therefore, buy on his own responsibility.

EXEMPTIONS FROM THE SEED LAW

In order that there may be no misunderstanding as to the exemptions from the provisions of the seed law, the text of the law regarding exemptions is hereby quoted in italics and followed by explanatory notes.

Section 344.— *Exemptions. Agricultural seeds or mixtures of same shall be exempt from the provisions of this article:*

1. *When exposed for sale or sold for food or feeding purposes only.*— No labels are required under the seed law when seeds are sold, offered, or exposed for sale for food or feeding purposes; however, just so soon as such seeds are sold, offered, or exposed for sale for seeding purposes on the land then the complete label must be attached.

2. *When sold to be recleaned before being sold or exposed for sale for seeding purposes.*— No labels are required when seeds are sold to elevator men, merchants, seed dealers, etc., to be recleaned before

being sold, offered, or exposed for sale for seeding purposes. In such cases the dealer or other person who recleans the seed to put it into salable condition for planting purposes must have the lot tested and must completely label each parcel of 10 pounds or more before it is placed on sale or sold. In other words, any farmer can sell his seed stocks of his own growing to any merchant to be recleaned without the necessity of labels; however, as soon as he takes it from his farm or sends it by common carrier to another for *seeding purposes*, then he becomes a vendor, and both the seller and the seeds are subject to all the provisions of the seed law.

3. *When held for the purpose of recleaning.*—When seeds are held in storage in any form or place for the express purpose of recleaning no labels are required until they are recleaned, held for sale, offered for sale, or sold for seeding purposes, then such goods must have the required label information.

4. *When such seeds consist of buckwheat, barley, corn, oats, rye, wheat, or other cereal sold by the grower thereof on his own premises and delivered to the vendee or his agent or representative personally on such premises.*—The meaning and intent of this exemption is quite clear, making it possible for one farmer to sell his seed barley, buckwheat, corn, oats, rye, wheat, and other cereals (that is, those grasses which are grown for their grain, which is ground into flour) of his own growing, on his own premises, to a neighboring farmer or other person providing he personally delivers such seeds to the "vendee" (the buyer) on such premises, that is the premises of the grower. The farmer may be held responsible for any representations he may make regarding such seeds. It should be clearly understood that none of the grasses or clovers with smaller seeds and which are more apt to be fouled with weed seeds can be sold in this manner for planting directly on the land. [Furthermore, no farmer, grower, or any other person can legally sell, offer, or expose for sale seeds for seeding purposes either of his own growing or farmer-bought for delivery from his farm or premises, either personally, by agent, or by common carrier unless such lot of seed is less than 10 pounds in weight (8 ounces of special mixtures), or is sold to be recleaned, or is fully and completely tagged with the required label information.]

FARMERS NOT EXEMPTED FROM THE SEED LAW

Farmers are not exempt from the seed law except as provided for in subdivision 4 of the exemptions discussed on page 539. The farmer should not be and is not fully exempted from the provisions of the seed law when he offers for sale seeds which are intended to be used immediately for seeding or planting purposes without further cleaning. His seed stocks offered for sale for planting purposes, except as above exempted, are subject to inspection and retest the same as those of any vendor of seeds, and his premises are also subject to inspection by authorized persons when there is reason to believe that the provisions of the seed law are being violated. He has not asked to be exempted and does not care to be since he has need of a strict seed law every time he purchases seeds for planting, whether of a dealer or of a neighbor. Seed laws which fully exempt the farmer have been found unconstitutional in other states. The careful, thrifty farmer demands, and rightly so, all the information about his contemplated seed purchase that is required to be given by the seed law. If a farmer, who is the grower thereof, desires to sell certain kinds of seeds to a neighbor without any label or quality information, and both care to deal in that manner, then they alone are responsible, the one for obtaining full price value for his goods and the other for the noxious and troublesome weeds he may get along with seed of possibly low or unknown germination.

SEED INSPECTION AND LAW ENFORCEMENT

The seed law, being an article of the State agricultural law, provides for the unobstructed inspection of any lot of seed in any place or upon any premises, the authorized representatives or agents of the Commissioner of Agriculture having access at all reasonable hours to such premises. Samples of seeds, properly drawn according to the rules for sampling seeds, may be taken in duplicate for the express purpose of examination, analysis, or test. Such tests are reported to the Commissioner of Agriculture who is empowered to administer the law in case he has reason to believe that its provisions have been violated.

RESULTS OF TESTS MAY BE PUBLISHED

The law provides for the publication from time to time of the results of the analyses or tests of samples of seeds procured on the market. This is done in order that the purchaser may study and compare the seed dealers' promises and performances from year to year. Additional information regarding the general condition of the quality of seeds and the seed trade may also be published with these reports if deemed necessary.

HOW A FARMER MAY SELL SEEDS

A farmer who is a grower of seeds and desires to sell them for seeding purposes may do so in a number of different ways.

1. He may sell any seeds to anyone, anywhere, for use for food without labels, or for seeding purposes when in less than 10-pound lots.

2. He may sell, ship, or deliver field seeds to any merchant or general market to be recleaned or graded before being offered for sale for seeding, just as he has always done.

3. He may sell buckwheat, barley, corn, oats, rye, and wheat seed or other cereal of his own growing to any person providing the seed is delivered personally to the buyer or his representative upon the premises of the grower.

4. He may sell any kind of seed for seeding purposes to anyone, anywhere, either to be delivered personally or shipped thru a common carrier providing he has either tested such seed, or has had a test made, as he should do, and has fully labeled each lot.

HOW A FARMER MAY BUY SEED

The law does not forbid any person from buying the cheapest and foulest seed upon the market or dead and trashy seed, if he cares to do so, nor does it shield him from his folly if he now buys seeds carelessly and without taking full advantage of the protection afforded by the seed law. Every lot of seed upon the market in this State must be fully labeled, and no farmer should accept such seed until he has made an examination of the statements on the tag or label. In case these statements are not given he should insist upon receiving such quality information as required by law and

should promptly report to the Commissioner of Agriculture at Albany any persons or dealers who are violating the seed law or ignoring its provisions.

The most important consideration which the farmer can possibly give to seed purchases is in the matter of the grade of seed. When a tag or label bears a statement that the seed is above 99 per cent pure, and since the farmer can find out, if he will, whether such a statement is true, he may be sure that he is buying fairly safely. However, when he buys seed which is labeled with a low percentage of purity, he may be certain that he is either buying dirt at seed prices, or else is getting a grand array of weed seeds which will most certainly bring him a huge expense bill in the form of eradication effort for years to come. Usually a low purity guaranty means cheap, but really costly, seed; and cheap seed, like cheap fertilizer, is always expensive. This is necessarily so since the competition on the seed market is so keen that seed grades are based very nearly on their actual value. There are no bargains in the seed market because cheap seed is cheap for the reason that it is poor in quality, and any farmer who buys cheap seed in order to save money is like the man who stops the hands of the clock to save time — there is no saving. Likewise, any farmer or grower who produces foul and dirty seed cannot expect a dealer to pay a high market price if he is forced to spend time and money in cleaning out dirt and inert matter, weed seeds, and the light trashy stuff that nearly always remains in seed when threshed.

Finally, the farmer should *buy good seed* of a desired and known kind or variety, fully and completely labeled. He should grasp the idea that purchased weed seeds and inert matter are highly expensive; furthermore, that buying "cheap seeds" carelessly, absolutely prevents one from having any control of the weeds upon the farm. On and after July 1, 1920, it will pay every New York farmer to buy his farm seeds of the local dealer, retailer, or State wholesaler, since they will sell their grades of seed under an honest and correct label as required by the State law. On the other hand, if a farmer sends outside the State for his seed he buys at his own peril because the out-state dealer sends seeds into this State under the freedom of interstate commerce and is immune to local prosecution except where contract of sale is made within the State. State laws

do not regulate interstate commerce, consequently the only protection for the farmer who sends for seeds outside the State is the reliability of the house with which he deals.

PURCHASERS MAY HAVE SEEDS TESTED

Anyone who purchases seeds for his own planting purposes may have them tested free of charge according to the rules and regulations for seed testing adopted by the Station officials as given on page 545. However, no person should send samples for testing until he is familiar with the rules for the sending of such samples. Since the seed law is primarily a labeling law it should be entirely possible for the purchaser to rely quite largely upon the label statements found upon the lots of seed in the hands of the local dealer or other persons favorably known to the purchaser. Plainly it should not be the function of the Station seed laboratory to be continually retesting labeled goods or recognized brands or lots of seeds found upon the market when there is no evidence to show that such label statements are incorrect, or where the date of the germination test does not show sufficient time to have elapsed to effect materially the germinative ability of the seeds.

If, in any case, the purchaser of seeds has good and sufficient reason to believe that the label markings are not true statements of facts concerning the seed, or that sufficient time, as shown by the date of the test, has elapsed to effect materially the viability of the seed, he may have them tested free of charge according to Rule 8, page 546.

Samples sent in for testing will be reported upon strictly in the order in which they are received. The report will include a statement of the purity of the sample, that is, it will give the percentage of pure seed, the percentage of weed seeds, the percentage and character of the inert matter, and the number per pound of crop seed of noxious weed seeds present.

The percentage of germination, or the number of seeds per 100 selected just as they come which will sprout in the normal number of days, will be stated on the report if a germination test is requested. The percentage of hard seeds, that is, those seeds which remain hard (having neither sprouted, swollen, nor decayed) at the end of the test period will also be given.

When it seems to the interest of the farmer or purchaser to do so, some additional remarks or comments as to the condition or quality of the seed will be made upon the report.

PROVISIONS FOR SEED TESTS

The seed law grants permission to the New York Agricultural Experiment Station at Geneva to establish and maintain a seed laboratory with necessary equipment, and to employ competent analysts to make analyses and tests of samples of seeds collected under the provisions of the seed law. Since 1905, this Station has made tests of seeds voluntarily and free of charge for farmers or purchasers of seed when the sample and the accompanying request for a test bore every evidence of being desired by the prospective sower of the seed. Samples in increasing numbers and to the extent of several hundred per year have been tested under this policy. It is to be hoped that farmers in increasing numbers will appreciate and will continue to take advantage of the facilities offered by the seed law in a provision for a seed testing laboratory where their seeds may be tested. Means and facilities have not been available with which to undertake testing for seed dealers and the general seed trade. Since 1912, when the first seed law was enacted in this State, samples collected officially from the open market have been analyzed at this Station as provided for in the law, however, no provision was made for the operation of a seed testing laboratory.

Provision is also made in the new law whereby any citizen of the State shall have the privilege of submitting to the seed laboratory at the New York Agricultural Experiment Station at Geneva, samples of agricultural seeds for test or analysis. This privilege is subject, however, to such rules and regulations as may be adopted by the Director and Board of Control of said Station. These officials are granted power to make such rules and regulations as may from time to time become necessary to protect the seed laboratory and to facilitate service for the greatest number of people by limiting the number of samples tested for any one individual in a given time, and also to fix the fee charged for making tests of samples other than those tested free of charge.

Rules and regulations adopted by the Director and Board of Control of the Station for the use of the seed testing laboratory

are given below. Unless these rules and regulations are strictly observed delay in testing will result, or the samples may receive no attention at all. No tests will be made for persons violating any of the regulations.

RULES AND REGULATIONS GOVERNING THE TESTING OF SEEDS FOR PURITY AND GERMINATION [1]

1. The kinds of seeds that will be tested are those specified in the Seed Law and, in addition, the seeds of garden and truck crop plants.

2. Samples to be tested should be drawn in such a way as to be fairly representative of the bulk lot of seed from which they are taken.

3. Only samples which are of sufficient size for taking a representative test-sample will be analyzed or tested. The minimum weight of seed forwarded for test should be approximately:

(a) One ounce of grass seed of any kind or of white and alsike clover;

(b) Two ounces of red and crimson clover, alfalfa, millet, flax, or seed of like size;

(c) One-half pound of cereals or seed of like size.

4. Each sample must bear an identification mark, the name of the kind of seed, and the name and address of the sender. Also, it must be accompanied by a statement of what is desired — whether a purity test, a germination test, or both.

Samples sent by mail or express must be fully prepaid and should be enclosed in stout containers which will insure their arrival unbroken.

Address all samples and correspondence relating thereto to the Seed Laboratory, New York Agricultural Experiment Station, Geneva, N. Y.

5. The name of the Station, of the Seed Laboratory, or of a Station official must not be used for advertising purposes in connection with the report issued upon any sample of seed.

The data on the report may be copied onto a tag or label for the purpose of a declaration of sale, but the party doing this thereby guarantees that the quality of the seed to which such label is attached equals that indicated by the label.

[1] Adopted by the Director and Board of Control of the New York Agricultural Experiment Station, June 1, 1920.

6. Samples of seed grown by residents of New York State for their own use will be tested free of charge. Such samples must be accompanied by a statement that the test is not desired for use in a declaration of sale or for purposes of labeling, but for guidance in planting.

7. For all tests the results of which are to be used for declarations of sale or for labeling purposes, a fee will be charged as follows: For purity tests of special mixtures and all grasses (except timothy and the cereal grains), one dollar each; for purity tests of timothy, cereal grains, and all other kinds of crop seeds (except grasses), fifty cents each; for all germination tests, twenty-five cents each. Remittance should be made by money order payable to the State of New York.

8. Only under special circumstances which seem to justify such analyses in order to check guarantees, will the Station make tests (other than the regular official tests) of labeled seeds offered for sale upon the market. Persons making request for such tests should state fully their reasons therefor and furnish the following information in addition to that required under paragraph 4:

(a) Name and address of the party offering the seed for sale;

(b) A complete copy of the label on the seed;

(c) The commonly accepted name of the seed, its variety, and place where grown, if known.

9. No more than five samples will be tested free for any one person in any calendar month, but such persons may have additional samples tested upon payment of the required fees. To avoid errors and consequent delays in testing, senders of samples should keep a record of their sendings.

10. No notice will be taken of samples which are unaccompanied either by a fee or the statement required for free-test samples as given in paragraph 6.

SHOULD THE ORCHARD BE FERTILIZED?*

J. D. LUCKETT

The need of orchard fertilizer experiments

Twenty-four years ago a fertilizer experiment with Rome Beauty apples was begun on the Station farm. After fifteen years, those in charge of the experiment reported that the trees "would have been practically as well off had not an ounce of fertilizer been applied to them. One must conclude that if fertilizers have no value in this orchard, they have no value in many other orchards in New York."

The question naturally arises as to what extent these conclusions are applicable to other soil conditions in the State and, consequently, a number of representative orchards were chosen for more extended fertilizer tests. In all, three apple orchards and one orchard each of cherries and pears were selected. A study has also been made of the effect of fertilizers on apple nursery stock and on grapes.

The complete bulletin describes in detail the fertilizing practice followed in each case and reports the progress of the experiments for the period of 1912 to 1919.

Unlike experiments with field crops which can be conducted under more or less controlled conditions on account of the small size of the individual plant, orchard investigations do not lend themselves to study under exact conditions because the tree is of particular interest only after it has come into full bearing. Trees undoubtedly require the same plant food elements as do other crops, but the proportions and amounts which will give the best results under any particular set of conditions is quite a different matter.

While comparatively little is known concerning the food requirements of fruit trees, it is probable that if a fertilizer experiment

* Reprint of Popular Bulletin No. 477, July, 1920. The Complete Bulletin is reprinted on p. 52.

could be continued over a long period of time — say 100 years — the exhaustion of the plant food reserve might become apparent in even the most fertile soils and with the best cultural conditions, providing no plant food was returned to the soil. Just when this would take place would depend on many factors such as the natural fertility of the soil, the size, kind, and number of crops removed, the fertility replaced either as fertilizer or as crop residues, loss of fertility thru drainage, etc. The maintenance of fertility in the orchard, therefore, may not be of vital importance to the present orchard-man, but it may be a very serious problem with succeeding generations.

Difficulties encountered in orchard experiments

Orchard experiments are also subject to many factors affecting the accuracy of the results which do not enter into field crop experiments. The most important of these are the lack of uniformity of the soil in the large areas required in orchard work; differences in the size, vigor, and character of the individual trees; the necessity of basing conclusions on the performance of a relatively small number of trees; the difficulty of duplicating the fertilizer treatments due to lack of uniformity in the soil; possible differences in the productiveness of trees from unknown stock; and the general uncertainty of cooperative experiments where the investigator cannot be present to supervise all the various operations.

Other experiments with fertilizers in the orchard

A review of investigations conducted in different parts of this country and in Europe shows a wide variation in the results secured following the use of fertilizers in orchards. The principal elements which enter into fertilizers to be used in the orchard are nitrogen, phosphorus, potassium, and lime, so that the importance of these and of manure in growth and fruit production, as indicated by the results of other investigators, has been studied in some detail

Summing up the results obtained by these other workers it is concluded that fertilizer tests with fruit trees have not given uniform results and that the problem of orchard fertilization is not yet solved. Different species of fruit also appear to differ in their response to fertilizers. Furthermore, the conditions under which the various experiments were conducted have been so different that the results are scarcely comparable.

Location of present experiments

Information relative to the present experiments is given in Table 1 in connection with which it should be stated that these orchards were selected with the following requirements in view: Uniformity as to drainage, topography, and character of soil; uniformity as to age and vigor of trees; and with reference to previous management.

TABLE 1.— INFORMATION RELATING TO THE PRESENT EXPERIMENTS.

FRUIT	ORCHARD	LOCATION	CHARACTER OF SOIL	NUMBER OF TREES	AGE OF TREES AT BEGINNING OF EXPERIMENT	YEAR EXPERIMENT BEGAN
Apple....	Densmore-Chapman	Albion	Reddish sandy loam	264	38 years	1912
Apple....	Auchter-Vick	Rochester	Loam	230	37 years	1914
Apple....	Great Bear	Fulton	Stony sandy loam	252	4 years	1913
Pear.....	Howard	Kinderhook	Sand to sandy loam	504	Just set	1912
Cherry...	O'Neil	Geneva	Loam	528	5–6 years	1913
Nursery stock, apples..	Smith Nursery	Geneva	Clay loam	6,600	....	1912
Grape....	Stone Vineyard	Fredonia	Shale loam	4 acres	....	1912

Evidence is available from various sources which demonstrates the importance of care in the selection of the experimental tract and the necessity of repeating the experiments over a long period of years before differences between variously treated plats can be regarded as significant. The present report on these experiments is, therefore, an account of progress only, and merely indicates what these orchards may be expected to do under the system of fertilization outlined.

General plan of treatment

The practice of orchard fertilization has varied from no fertilizer to the application of large amounts, while experimental evidence of the best amount is quite meagre or lacking altogether. It was thought that a study of the amount of plant food removed from the soil by the various fruits would aid in the formulation of a rational fertilizer treatment. The fertilizer applications outlined in Fig. 46 are based, therefore, on information secured from other experiments, on the composition of the crop removed, and on general fertilizer practice. The amount of plant food given in each case is thought to represent a sufficient supply for full crop production and for the maintenance of soil fertility. This plan of treatment was modified in some instances to meet special conditions.

Owing to the high price and scarcity of potash during the war this element was not applied to these orchards during 1916 and 1917. Also, during these two years, dried blood was substituted for nitrate of soda.

Records were taken of the increases in trunk diameter and of the yields of fruit for the different fertilizer plats.

The Densmore-Chapman apple orchard

The Densmore-Chapman orchard is a Baldwin apple orchard and is located on a fertile reddish loam soil containing a considerable amount of sand. The subsoil is quite similar to the surface soil. The trees in this orchard originally stood 33 by 33 feet, but several years before the experiment began all but eight rows were thinned to stand 47 by 66 feet. In 1918, the remaining eight rows were also thinned. The

orchard was kept in sod up to 1910 and received about 10 loads of manure once in two years. In 1912, 1913, and 1914, red clover was used as a cover crop; in 1915, 1916, and 1917, alfalfa; and in 1918, alsike clover. During 1913 to 1916 the orchard was divided into

No. of plat	
1	45 lbs. nitrogen from nitrate of soda.* 25 lbs. phosphorus from acid phosphate. 100 lbs. potassium from muriate of potash.
2	No treatment.
3	45 lbs. nitrogen from nitrate of soda. 40 lbs. phosphorus from acid phosphate. 50 lbs. potassium from muriate of potash.
4	45 lbs. nitrogen from nitrate of soda. 40 lbs. phosphorus from acid phosphate.
5	45 lbs. nitrogen from nitrate of soda.
6	No treatment.
7	40 lbs. phosphorus from acid phosphate. 50 lbs. potassium from muriate of potash.
8	40 lbs. phosphorus from basic slag. 50 lbs. potassium from muriate of potash.
9	120 lbs. phosphorus from raw rock phosphate. 50 lbs. potassium from muriate of potash.
10	No treatment.
11	40 lbs. phosphorus from acid phosphate. 2 tons ground limestone once in 3 years.

* Pounds per acre.

FIG. 46.—ARRANGEMENT AND GENERAL TREATMENT OF THE PLATS.

two equal parts cross-wise of the plats and the cover crop allowed to remain one year on the north half, while the same year the south half was clean cultivated. A cover crop was then sown on the south half in the late summer and the following spring the whole orchard was plowed and tilled during the season and the cover crop sown as usual, while the next spring the south half was left and the north half tilled, etc. However, the whole orchard was tilled in 1916, 1917, 1918, and 1919.

The orchard bore only fairly well up to 1908, while the average yield for the period of 1908 to 1912 was about 300 barrels per year.

The yields of fruit obtained from the variously treated plats have been very irregular so far as showing any particular benefit from the different fertilizer treatments. In a general way, it appears that nitrogen alone or combinations of fertilizers containing nitrogen have increased the yields, but comparisons between the combinations themselves have been so peculiar that the value of fertilization in this orchard has not been proved.

In addition to data on total yields, observations were also made on the relative yields of first grade fruit and of culls, on the size of fruit for the three years of largest crop production, and on the increase in trunk diameter.

To summarize the results secured, it may be stated **that up to the present time fertilization has not given returns sufficient to justify the necessary outlay for the fertilizers and for the labor involved in their application. The yield, which is of first importance to the orchardist, was not consistently increased, there was no marked improvement in the color or size of the fruit, and the growth increases, as indicated by trunk diameter, were quite small.**

The Vick and Dildine apple orchard

The Vick and Dildine orchard for 10 years previous to the inauguration of the fertilizer experiments had been used in a sod and tillage experiment, conducted by the Department of Horticulture of this Station, so that an accurate record of its performance for that time is available. The orchard is a Baldwin apple orchard and is located on a fertile loam soil with a sandy subsoil. The trees stand 40 by 40 feet. Red clover has been used as a cover crop, and the practice of leaving one-half of the orchard in clover during alternate years has been followed up to 1919. The orchard has been fairly productive.

With regard to the yields secured from the different fertilizer treatments, the results have been erratic and are inconsistent when the treatments are compared. There was also very little connection to be seen between fertilizer treatment and the percentage of good fruit and culls. Nitrogen seemed to increase trunk growth to a small extent, while three different forms of phosphorus in combination with potash had no effect.

The most striking fact observed in the results with this orchard was the apparent non-response to fertilizers in general. The accidental and chance differences in the results were greater than any differences which could be attributed to the fertilizers.

The Great Bear apple orchard

The Great Bear orchard is a Northern Spy orchard and is located on a stony, sandy loam soil with a sand and gravel subsoil. The trees stand 40 by 40 feet. The orchard has not yet borne a crop of apples, and altho it has not had the care that a young orchard should have, the trees are of good size and vigor.

The only data available up to the present time relate to the increase in trunk diameter on the different fertilizer plats. **There appears to have been an increase in growth on all the fertilizer plats, altho when the effects of the various combinations of fertilizers are compared the increases are not consistent.** Phosphorus apparently increased growth more than nitrogen alone, while basic slag increased growth more than acid phosphate or rock phosphate.

The O'Neil cherry orchard

The O'Neil orchard is a Montmorency cherry orchard and adjoins the Experiment Station farm at Geneva. It is situated on a very stony, somewhat sandy loam soil and had received no fertilizers previous to the beginning of the experiment. The trees stand 18 by 18 feet.

Fertilizers have, in general, increased the yield of cherries in this orchard, particularly those fertilizers containing nitrogen. Basic slag and raw rock phosphate seemed to be superior to acid phosphate, but the differences were rather insignificant. However, from a practical standpoint, the application of fertilizers to this orchard has been unprofitable.

The fertilizers applied to the complete fertilizer plat (Fig. 46), which gave the largest increase in yield, cost $9.70 per year with nitrate of soda at $75, acid phosphate at $25, and muriate of potash at $120 per ton. An additional charge of 65 cents for mixing and applying the fertilizer makes the total cost of treatment for this plat $10.35. The increased crop was estimated at 25 pounds per tree for the seven years, 1913 to 1919. Using 16 trees per plat as an average, there was a total increase of 400 pounds, or about 60 pounds per year. With cherries at 10 cents per pound, the value of the increased yield was $6.00, as compared with a cost of producing the increase of $10.35.

The fertilizer treatments increased the mid-trunk diameter of the trees in every case.

The Howard pear orchard

The Howard pear orchard is a Kieffer orchard and is situated on a fine sand to sandy loam soil of considerable depth with a sand and gravel subsoil. The trees are set 20 by 20 feet. The only fertilizer the trees had received previous to the beginning of these experiments was two forkfulls of manure per tree at time of setting. The orchard has been under cultivation thruout the experiment. There has been no crop worth recording up to the present time.

With regard to the increase in mid-trunk diameter on the variously fertilized plats, **the results have been so erratic that no definite conclusions have been reached, altho it is evident that fertilizers have not affected the diameter growth.**

Experiments with apple nursery stock

The production of nursery stock, where from 5,000 to 10,000 trees are grown on an acre of land, undoubtedly makes a heavy drain on the reserve fertility of the soil. It is essential, therefore, that the soil be fertile, well drained, and well supplied with organic matter. The experiments conducted in the Smith nursery (Table 1) were planned to show the effect of fertilizers in hastening the growth of apple nursery stock. The nursery is located on a fertile, tile-drained, clay loam soil. The plan of treatment (Fig. 47) was somewhat different from that followed in the orchard experiments.

No. of plat	
1	1,000 pounds acid phosphate.*
2	No treatment.
3	2,000 pounds rock phosphate.
4	4,000 pounds rock phosphate.
5	16 tons manure.
6	No treatment.
7	2,000 pounds rock phosphate and 16 tons manure.
8	2,000 pounds rock phosphate and 500 pounds muriate potash.
9	500 pounds muriate of potash.
10	No treatment.
11	4,000 pounds rock phosphate and 2 tons limestone.

* Pounds per acre.

FIG. 47.—PLAN OF TREATMENT IN APPLE NURSERY EXPERIMENT.

The treatments above outlined were given only once, in 1912, when the experiment was begun. In the spring of 1913 and again in 1914, one-half of each plat was given, in addition, 300 pounds of nitrate of soda per acre.

There were 20 rows of Baldwins, 8 rows of McIntosh, and 7 rows of Oldenburg apples in the fertilizer experiment. In the fall of 1914 all the trees were calipered and averages taken for each plat.

From the results secured it appears that the Baldwins made larger trees than either the McIntosh or Oldenburgs. The only positive effects of fertilizers on tree growth were obtained on Plats 7, 8, 9, and 11. **Rock phosphate and manure and rock phosphate**

and potash increased the growth of both McIntosh and Baldwin stock. Potash alone increased the growth of McIntosh but not of Baldwin. In no case has nitrate of soda given a significant increase in growth. It is concluded that nitrogen, either as nitrate or in manure, has not increased the growth of nursery trees.

The vineyard experiment

As the grape industry developed in past years in this State, the vineyards have been extended to the poorer soil types on the higher elevations where the soil is poorly drained, often quite stony, and the surface soil shallow. Since the general character of the soil in these poorer vineyards is such an important factor, it was thought that the production of grapes might be made more profitable if a systematic method of soil improvement were adopted either before or at the time the vineyard was set out, followed with good treatment afterward. With this object in view, an experimental tract was selected on a shale loam soil near Fredonia. The tract was tile drained in the early spring of 1912 and was then plowed, one-half about 12 inches deep crosswise of the plats and the other half to the ordinary 7-inch depth.

Each plat consists of two rows of vines 320 feet long with 8½ feet between rows and 8 feet between the vines in the row. The arrangement and treatment of the plats is shown in Fig. 48.

The phosphates were applied in the summer of 1912, one-half of each before and one-half after plowing, and in the spring of 1913 the limestone was applied. The roots were set in 1913, after which

No. of plat	
1	2,000 pounds rock phosphate.*
2	4,000 pounds rock phosphate.
3	Check.
4	Complete fertiliser annually after setting: 200 pounds acid phosphate, 250 pounds nitrate of soda, and 50 pounds muriate of potash.
5	2,000 pounds acid phosphate.
6	2,000 pounds acid phosphate and 4 tons limestone.
7	Check.
8	4,000 pounds rock phosphate and 4 tons limestone.
9	4 tons limestone.

* Pounds per acre.

FIG. 48.— PLAN OF TREATMENT IN VINEYARD EXPERIMENT.

the whole vineyard received an application of two tons of ground limestone per acre except one-half of each check plat. The vineyard has been well cared for, cultivated each year, and a cover crop sown late in the summer. Marked differences were noted in the growth of the cover crops on the treated and untreated plats, that on the check plats being quite poor. The vines began to bear in 1915 and have borne each year since.

The complete fertilizer has given a considerable increase in yield, but with this exception it is concluded that other factors besides the fertilizers used have been responsible for the variations in yield. Due to the fact that complete fertilizer has increased the yield, it is thought that possibly available nitrogen is an important factor in this vineyard. Consequently, a new plan of treatment has been outlined which will introduce this factor and which will at the same time show the effect of manure and potash.

Summary and conclusions

So far as positive results are concerned, the experiments to date have been disappointing. Other factors evidently have masked any differences which may have been due to the fertilizers applied. Trees which have not received good care, orchards on poor soils, and orchards which must compete with other crops for plant food undoubtedly respond to the addition of available plant food as indicated by other experiments. However, the orchards used in these experiments are evidently not of that sort and many years of fruit production may be necessary before they show lack of available plant food.

Several of the soils used in these investigations were expected to respond to fertilizer treatment with fruit trees, but at present it must be concluded that **on the better fruit soils of this State fertilizers have, in general, failed to give differences in tree growth and fruit yields which can be readily distinguished from differences due to other causes.**

THE COST OF PRODUCING GRAPES IN THE CHAUTAUQUA AND LAKE ERIE FRUIT BELT*

J. D. LUCKETT

Cost of production an aid in determining selling price

The grape grower and the large users of grapes have long differed as to what constitutes a fair price for the crop. Unquestionably the selling price should depend primarily upon the cost of production, but an uncertain demand from year to year and a lack of definite information as to what the crop actually cost the grower have tended to render the market very unstable. Accurate data as to the cost of various operations entering into the growing and harvesting of the grape crop are very difficult to obtain due to the fact that no two vineyards are handled in exactly the same way. However, a careful study of the costs incurred in operating plantings worked in a similar manner should show, in a general way, what constitutes a fair charge for the various items involved in vineyard management and should aid both the grower and the buyer in arriving at an equitable price.

Factors affecting cost of production

Numerous factors must be taken into consideration in estimating the cost of producing grapes. For convenience these may be divided into three general groups as follows: (1) Maintenance including interest on investment, taxes and insurance, fertilizers, posts and wire, green manure seed, spray materials, and vine replacements. (2) Labor including pruning, spraying, trellis repair, tying, and cultivating. (3) Harvesting including picking, hauling, and containers.

Methods of vineyard management vary to such an extent that certain of these items would not enter into the calculation in some

* Reprint of Popular Bulletin No. 479, December, 1920. The Complete Bulletin is reprinted on p. 413.

vineyards; while, in other cases, items not mentioned here would require consideration. For example, an interview made in 1909 with some 500 growers in the Chautauqua and Lake Erie fruit belt showed that there was considerable difference in the fertilizer practice and tillage methods followed in that section. The investment in posts, wire, tools, etc. varied from year to year in the same vineyard and to a much greater degree in different vineyards in the same locality. The posts deteriorate more rapidly in some soils than in others. Many growers spray regularly, but the great majority have never done so. Pruning varies materially due to the method followed.

The age of the vineyard is an important factor due to its effect upon production. Extended observations in this region indicate that the vineyard should be in its prime at from 6 to 25 years of age, altho most vineyards fail rapidly after the twentieth year. Unfavorable soil conditions, depleted fertility, over-cropping, and infestation of the grape-root worm all contribute to this deterioration.

Costs studied in three vineyards

Data have been obtained on the costs incurred over a period of five years, 1915 to 1919, for three vineyards designated as E, R, and S, respectively, and situated in widely separated parts of the Chautauqua and Lake Erie fruit belt. Vineyard E, comprising 20 acres, was located on Dunkirk clay to clay loam soil; vineyard S, of 6 acres, on Dunkirk clay loam and gravelly loam; and vineyard R, of about 8 acres, on Dunkirk clay to clay loam soil.

The results of this study are regarded only as an indication of the outgo and income from vineyards worked in a similar manner and have, therefore, a limited application. The amounts expended in two of the vineyards probably exceed those spent in the majority of vineyards in this section or in any section of the State.

Unfavorable climatic conditions during two of the five years influenced the amount of labor employed in the vineyards and also the crop produced. However, the five-year period under consideration differed no more in this respect than did the five years immediately preceding. It is believed that climatic hazards should be taken into account in determining the selling price of grapes.

Charges for interest and labor

Since vineyards, similar to the ones under observation, were selling for $300 per acre at the time this work was begun, it was decided that this valuation would be a fair one upon which to base the investment in land. It was also agreed to charge interest on the investment at the rate of 6 per cent.

In 1915 team and man hire was charged at the rate of $5.00 per day, single horse and man at 35 cents per hour, and day labor at $2.00 per day. These rates, of course, increased materially during the period of study, and while Vineyards E and R met the increases

from year to year, the rates paid in Vineyard S did not rise until 1918 due to a long-time contract which had been made at stipulated prices.

In 1919 the rate for team and man in Vineyard E had advanced to 70 cents per hour, for single horse and man to 50 cents per hour, and for day labor to 40 cents per hour. In 1918 and 1919, the owner of this vineyard used a tractor for part of the work and this was charged for at the rate of $1.20 per hour in 1918 and $1.40 per hour in 1919. These charges include the services of the operator.

In Vineyard R the rate paid for team and man advanced to $8.00 per day, for single horse and man to 60 cents per hour, and for day labor to $4.00 per day.

Team and man hire advanced to $6.00 per day in Vineyard S, single horse and man hire to $4.50 per day, and day labor to $2.75 per day.

Pruning was regarded as a more specialized work than ordinary labor and was paid for at the rate of from 5 to 10 cents per hour more than day labor.

Women were usually employed for spring tying and for picking and were paid at the rate of from 15 cents per hour in 1915 to 30 cents per hour in 1919. Proximity to large towns tended to keep these rates lower than those paid for similar work in more remote districts.

Comparison of the vineyards

Altho the vineyards studied were located in widely separated parts of the grape belt of western New York, probably two-thirds of the vineyards of the section are on soils similar to those of Vineyards E and R, while a portion of Vineyard S is on much the same sort of soil. Consideration of the data secured from these vineyards should throw some light, then, on the principal factors affecting the cost of producing grapes in this region.

In Table 1 is given the average amount expended both per acre and per ton in each vineyard for the several items entering into the growing and harvesting of grapes for the five years, 1915 to 1919, inclusive. From these figures it is possible to determine the average cost of production; and, together with the average yield per acre and the average selling price per ton, to estimate the average net profit.

Application of the results

It cannot be too strongly emphasized that results secured in studies of this sort are of rather limited value so far as they may be applied to conditions other than those under which they were obtained. The unsettled state of prices for labor and materials of all kinds which existed during the greater part of the period covered by these studies should be taken into consideration by the grape grower in any attempt to apply the results to his own

conditions, and due allowance should be made for circumstances peculiar to his own locality and to the present time in drawing any deductions from these results.

TABLE 1.—AVERAGE COST OF PRODUCTION AND AVERAGE NET RETURN IN THE THREE VINEYARDS, 1915–1919.

ITEMS	ACRE BASIS			TON BASIS		
	Vineyard E	Vineyard S	Vineyard R	Vineyard E	Vineyard S	Vineyard R
Interest on investment	$18.00	$18.00	$18.00	$13.649	$8.494	$8.15
Taxes and insurance	1.01	3.65	4.47	.769	1.733	2.06
Fertilizer, manure, lime	6.31	15.56	6.31	6.010	7.626	2.50
Posts, wire, wire-ties, tools, etc	1.39	2.86	2.46	1.090	1.259	1.24
Green manure seed	1.94	2.48	.71	2.413	1.169	.35
Spray materials	.85	1.24	.80	.446	.765	.37
Vines for replacement	.06	....	.93	.035	......	.39
Total maintenance	$29.56	$43.79	$33.69	$24.412	$21.05	$15.07
Pruning	$3.44	$4.252	$3.50	$2.774	$2.185	$1.606
Brush disposal	1.42	1.742	2.95	1.000	.841	1.444
Trellis repair	1.49	2.194	3.03	1.018	.991	1.190
Tying, spring	1.64	1.424	2.18	1.251	.736	1.002
Plowing, single-horse	.25	1.820	.80	.304	1.036	.393
Plowing, team	1.99a	1.082	1.15	1.455	.515	.544
Horse hoeing	.82	1.488	1.59	.861	.813	.698
Hand hoeing	.70	1.224	2.16	.825	.591	.786
Harrowing	3.27	4.270	6.03	3.165	2.005	3.130
Clipping tops	......	.231	.38	......	.112	.171
Summer tying	......	.396	.51	......	.217	.267
Spraying, labor	.90	.806	.96	.513	.420	.467
Applying fertilizer	.63	......	......	.561	......	....
Green manure seeding	.56	.562	.14	.552	.261	.066
Miscellaneous	.61	.282	1.34	.267	.139	.564
Total labor	$17.72	$21.774	$26.72	$14.547	$10.86	$12.33
Total upkeep	$47.28	$65.56	$60.41	$38.959	$31.91	$27.40
Harvesting	$13.16	$17.66	$18.33	$8.963	$6.82	$7.69
Total cost of production	$60.44	$83.22	$78.74	$47.922	$38.73	$35.09
Yield, tons per acre	1.81	2.62	2.55	1.81	2.62	2.55
Selling price per ton	$66.48	$66.58	$67.64	$66.48	$66.58	$67.64
Net profit	39.30	73.88	86.76	18.56	27.85	32.54

a Includes charge for tractor.

With due regard for the above limitations, it may be stated that the average cost of production for the three vineyards during the five years was $74.13 per acre, and the average cost per ton of grapes $40.58. The average net profit per acre was found to be $66.64 and the average profit per ton $26.31. These figures vary considerably from year to year and in Vineyard E an actual loss was sustained in two of the five years. However, the averages for the five years tend to smooth out differences due to seasonal factors and are, therefore, a more accurate index to the general trend of costs and profits.

An examination of the table shows that Vineyards R and S have given a considerably higher return both per acre and per ton of grapes than Vineyard E altho the latter was operated at a lower cost per acre than the other two. However, the higher yields secured in Vineyards R and S, due largely to improved tillage and fertility practices, have overcome the increased cost of production in these vineyards. Also, Vineyards R and S are relatively small acreages as compared with Vineyard E and probably represent more uniform soil conditions. Without doubt soil irregularities frequently render vineyards unprofitable.

Possibilities in other vineyards

Many vineyards in this region are operated at costs equal to those of Vineyards R and S and return as large or even larger profits, but most of the acreage in this section is maintained at less expense and gives a return corresponding more nearly to that realized from Vineyard E. The question naturally follows as to whether these plantings can be made as profitable as Vineyards R and S; but in view of the fact that many of them are situated on soils unsuited to grape growing, while others include areas that never can be made profitable, it is doubtful if they will ever attain that level.

The three vineyards under observation have been improving, or at least holding their own, but the great majority of vineyards in this region have been slowly but surely declining, altho vineyards on the better soil types can probably be made to produce larger and more uniform crops.

It is concluded from these studies that under intensive management grape growing in the Chautauqua and Lake Erie fruit belt can be made profitable even with the present high cost of labor and supplies if the selling price of the crop can be maintained at or near the level of the 1918 and 1919 seasons.

PERIODICALS RECEIVED BY THE STATION

Abstracts of Bacteriology	Subscription
Agricultural Gazette of Canada	Complimentary
Agricultural Gazette of New South Wales	Complimentary
Agricultural Journal of India	Complimentary
Agricultural Review	Subscription
American Agriculturist	Subscription
American Chemical Society Journal	Subscription
American Entomological Society (Transactions)	Subscription
American Fertilizer	Subscription
American Florist	Subscription
American Fruit Grower	Subscription
American Grocer	Complimentary
American Journal of Botany	Subscription
American Journal of Physiology	Subscription
American Journal of Science	Subscription
American Library Association, Bulletin and Booklist	Subscription
American Museum of Natural History, Bulletin	Complimentary
American Naturalist	Subscription
American Philosophical Society, Proceedings	Subscription
American Poultry Advocate	Complimentary
American Seedsman	Exchange
American Society of Agronomy, Journal	Subscription
Analyst	Subscription
Annales de L'Institut Pasteur	Subscription
Annali della R. Scuola sup. d'Agriculture, Portici	Complimentary
Annals and Magazine of Natural History	Subscription
Annals of Applied Biology	Subscription
Annals of Botany	Subscription
Annals of the Missouri Botanical Garden	Subscription
Archiv. für Hygiene	Subscription
Archiv. für Physiologie (Pflüger's)	Subscription
Arnold Arboretum, Bulletin	Complimentary
Berichte der deutschen botanischen Gesellschaft	Subscription
Berichte der deutschen chemischen Gesellschaft	Subscription
Berichte über die gesamte Physiologie	Subscription
Better Business	Exchange
Better Fruit	Subscription
Biedermann's Zentralblatt	Subscription

Biochemische Zeitschrift .... Subscription
Biological Bulletin .... Subscription
Biologisches Centralblatt .... Subscription
Boletim de Agricultura .... Complimentary
Boletin de la Sociedad Entomologica de Espana .... Complimentary
Botanical Abstracts .... Subscription
Botanical Gazette .... Subscription
British Food Journal .... Subscription
Bulletin tri. Société Mycologique .... Subscription

California Academy of Sciences, Proceedings .... Complimentary
California Cultivator .... Subscription
California Fruit News .... Subscription
California University Publications — Agricultural Sciences, Botany, and Zoology .... Complimentary
Canadian Entomologist .... Subscription
Canadian Horticulturist .... Complimentary
Canner .... Exchange
Centralblatt für Bakteriologie, Parasitenkunde, und Infektions krankheiten .... Subscription
Chemical Abstracts .... Subscription
Chemical Society, Journal .... Subscription
Chemisches Zentralblatt .... Subscription
Chicago Dairy Produce .... Complimentary
Climatological Data .... Complimentary
Commercial Fertilizer .... Subscription
Congressional Record .... Complimentary
Conservationist .... Subscription
Country Gentleman .... Subscription
Creamery and Milk Plant Monthly .... Subscription
Curtis's Botanical Magazine .... Subscription

Dairy Farmer .... Subscription
Duroc Bulletin .... Complimentary

Ecology .... Subscription
Entomological News .... Subscription
Entomological Society of America, Annals .... Subscription
Entomological Society of Washington, Proceedings .... Subscription
Entomologist .... Subscription
Entomologist's Record .... Subscription
Experiment Station Record .... Complimentary

Farming .... Complimentary
Farm Journal .... Complimentary
Farmers' Advocate .... Complimentary
Florida Entomologist .... Complimentary

Florists' Exchange	Subscription
Flour and Feed	Subscription
Garden	Subscription
Gardeners' Chronicle	Subscription
Garden Magazine	Subscription
Gartenwelt	Subscription
Gleanings in Bee Culture	Subscription
Gli Insetti	Subscription
Hawaiian Forester and Agriculturist	Complimentary
Hoard's Dairyman	Subscription
Hospodar	Complimentary
Insect World (Japanese)	Complimentary
Internationale Mitteilungen für Bodenkunde	Subscription
International Garden Club, Journal	Subscription
International Review of Science and Practise of Agriculture	Complimentary
International Review of Agricultural Economics	Complimentary
Journal of Agriculture, New Zealand	Complimentary
Journal of Agricultural Research	Complimentary
Journal of Agricultural Science	Subscription
Journal of American Association Cereal Chemists	Exchange
Journal of American Medical Association	Subscription
Journal of the American Peat Society	Subscription
Journal of Association of Official Agricultural Chemists	Subscription
Journal of Bacteriology	Subscription
Journal of Biological Chemistry	Subscription
Journal of Ministry of Agriculture (English)	Complimentary
Journal of the College of Agriculture, Tokyo	Complimentary
Journal of Dairy Science	Subscription
Journal of the Department of Agriculture of South Australia	Complimentary
Journal of the Department of Agriculture of Victoria	Complimentary
Journal of Experimental Medicine	Subscription
Journal of Experimental Zoology	Subscription
Journal of General Physiology	Subscription
Journal of Genetics	Subscription
Journal of Heredity	Subscription
Journal of Hygiene	Subscription
Journal of Immunology	Subscription
Journal of Industrial and Engineering Chemistry	Subscription
Journal für Landwirtschaft	Subscription
Journal of Pathology and Bacteriology	Subscription
Journal of Physical Chemistry	Subscription
Journal of Physiology	Subscription

Journal of Pomology	Subscription
Journal für praktische Chemie	Subscription
Landwirtschaftliche Jahrbuch der Schweiz	Subscription
Landwirtschaftliche Jahrbücher	Subscription
Landwirtschaftliche Versuchs Stationem	Subscription
Leghorn World	Complimentary
Market Growers' Journal	Complimentary
Market Reporter	Complimentary
Memoirs of the Department of Agriculture in India	Complimentary
Michigan Farmer	Complimentary
Milchwirtschaftlisches Zentralblatt	Subscription
Monthly Bulletin, International Institute of Agriculture	Complimentary
Monthly Bulletin of the N. Y. State Department of Health	Complimentary
Monthly Crop Reporter	Complimentary
Monthly Weather Review	Complimentary
Mycologia	Subscription
National Farmer	Complimentary
National Nurseryman	Subscription
National Weather and Crop Bulletin	Complimentary
Naturaliste Canadienne	Complimentary
New York Academy of Science, Annals and Transactions	Subscription
New York Botanical Garden, Bulletin	Complimentary
New York Entomological Society, Journal	Subscription
New York Produce Review	Subscription
New York State Museum Bulletins	Complimentary
Northwestern Miller	Complimentary
Ohio Farmer	Complimentary
Ohio Journal of Science	Subscription
Pacific Dairy Review	Complimentary
Pacific Poultry Breeder and Fanciers' Monthly	Subscription
Parasitology	Subscription
Phytopathology	Subscription
Potato Magazine	Subscription
Poultry Herald	Subscription
Poultry Item	Complimentary
Power	Subscription
Proceedings Boston Society of Natural History	Complimentary
Produce Packer	Subscription
Psyche	Subscription
Reclamation Record	Complimentary
Reliable Poultry Journal	Subscription

Review of Applied Entomology	Subscription
Revue de Viticulture	Subscription
Revue Générale de Botanique	Subscription
Revue Horticole	Subscription
Royal Agricultural Society, Journal	Subscription
Rural New Yorker	Subscription
Science	Subscription
Seed World	Subscription
Société Entomologique de France, Bulletin	Complimentary
Soil Science	Subscription
Station Agronomique de la Guadeloupe, Journal, Bulletin, and Reports	Exchange
Stazione Sperimentale Agrarie Italiane	Complimentary
Torrey Botanical Club, Bulletins and Memoirs	Subscription
Wallace's Farmer	Complimentary
Wilson Bulletin	Complimentary
Zeitschrift für analytische Chemie	Subscription
Zeitschrift für Biologie	Subscription
Zeitschrift für Botanik	Subscription
Zeitschrift für Pflanzenkrankheiten	Subscription
Zeitschrift für Pflanzenzuchtung	Subscription
Zeitschrift für Physiologische Chemie	Subscription
Zeitschrift wissenschaftliche Insektenbiologie	Subscription
Zentralblatt Biochemie u. Biophysik	Subscription
Zoölogische Anzeiger	Subscription

METEOROLOGICAL RECORDS FOR 1920

METEOROLOGICAL RECORDS FOR 1920

READING OF STANDARD AIR THERMOMETER FOR 1920

DATE	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	35	28	20	4	15	22	14	24	25	49	71	70	40	40	40	67	85	76
2	0	10	7	22	36	40	0	31	34	50	56	54	39	45	49	70	80	80
3	10	13	10	30	27	22	12	32	32	41	52	51	40	49	50	62	68	62
4	5	9	4	15	25	20	31	30	40	27	28	30	43	50	51	50	64	63
5	7	14	13	19	23	24	40	24	18	42	34	36	42	56	58	54	57	55
6	15	25	27	22	27	30	12	9	11	24	34	36	45	64	63	50	52	52
7	28	30	36	26	30	29	7	11	14	29	30	31	48	65	66	50	67	74
8	34	34	31	24	27	24	11	22	26	22	30	26	48	59	60	59	64	63
9	25	23	18	20	25	22	25	35	39	27	33	34	45	50	52	57	73	78
10	12	23	22	30	34	31	38	41	45	29	38	37	52	50	48	65	85	85
11	25	29	26	22	29	27	48	45	43	34	38	41	42	48	54	75	84	79
12	19	20	18	26	38	38	45	51	56	40	46	49	42	52	53	72	80	72
13	33	35	24	23	32	29	25	25	20	29	32	34	44	54	55	62	75	76
14	12	9	6	26	35	41	10	14	14	35	45	48	41	48	50	63	81	80
15	8	10	2	14	15	7	14	36	41	40	48	45	41	50	55	69	81	71
16	—7	8	6	6	9	8	40	52	53	35	48	51	49	63	65	66	64	61
17	20	10	12	18	31	29	34	38	31	39	51	50	50	70	68	55	60	58
18	8	10	7	31	21	16	26	33	31	41	56	55	49	69	70	52	54	55
19	8	10	10	5	16	15	24	34	31	45	58	58	59	72	74	55	66	70
20	3	10	17	8	23	23	31	31	33	44	63	65	56	74	63	61	74	71
21	16	16	13	8	26	28	26	36	38	46	53	54	59	73	68	54	66	65
22	1	15	9	24	29	27	35	50	54	45	59	63	55	70	68	59	69	65
23	21	24	23	15	28	31	48	64	66	51	62	51	57	71	70	57	70	67
24	15	15	13	28	30	28	43	66	63	40	41	44	56	64	60	59	71	70
25	7	10	9	12	21	20	41	63	68	24	45	49	56	69	65	61	75	74
26	4	17	21	12	10	5	51	65	56	40	55	55	58	75	71	66	82	80
27	34	38	35	2	10	10	42	38	39	44	47	43	61	81	80	63	82	89
28	18	18	11	5	20	23	34	55	57	43	52	49	50	74	70	66	85	87
29	6	19	21	18	21	20	52	59	44	39	42	50	55	66	64	77	90	80
30	30	29	19	....	....	....	34	49	56	47	52	50	61	75	76	74	81	80
31	—9	—7	—5	....	....	....	37	67	50	....	....	....	61	78	79	....	....	....
AVERAGES	14.1	17.8	15.0	18.1	24.6	23.7	30.0	39.7	39.9	38.0	46.6	46.6	50.0	62.0	61.5	61.7	72.8	71.3

READING OF STANDARD AIR THERMOMETER FOR 1920 (*concluded*)

Date	July			August			September			October			November			December		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	62	72	74	65	67	65	58	79	70	45	47	46	46	42	40	40	42	39
2	64	75	74	56	60	60	52	64	67	43	54	53	50	51	53	40	38	35
3	65	80	72	60	68	68	55	70	71	49	67	68	43	46	45	39	38	39
4	57	62	54	59	75	78	52	74	77	54	72	69	43	49	47	45	50	51
5	60	72	74	65	80	76	55	75	73	45	49	47	48	50	47	44	43	47
6	61	79	82	66	77	76	61	69	70	44	56	56	36	49	44	33	33	34
7	68	69	72	70	84	78	63	69	68	37	61	66	39	46	40	30	31	30
8	62	71	70	67	84	87	60	73	74	45	69	74	43	49	45	25	24	22
9	64	73	69	70	85	73	56	76	74	47	72	76	43	56	58	21	28	25
10	65	79	78	72	81	66	63	69	66	54	65	67	35	35	33	27	34	33
11	66	77	76	67	75	81	56	75	73	58	65	67	34	45	40	32	33	33
12	66	80	75	69	84	82	65	81	83	60	69	68	25	27	23	33	40	39
13	71	85	80	71	75	74	60	64	65	49	70	72	23	30	30	39	43	42
14	72	81	76	70	82	83	55	70	69	55	73	76	29	31	38	51	51	45
15	65	80	73	68	80	78	52	71	73	56	80	78	32	36	35	35	39	33
16	56	68	72	70	77	69	60	74	71	55	75	62	30	35	34	31	32	30
17	58	72	74	70	80	74	50	64	63	57	64	63	32	35	30	29	32	30
18	65	67	76	67	73	77	65	73	74	52	65	69	35	41	35	30	32	30
19	67	74	73	65	79	79	46	54	53	52	62	60	35	41	36	28	30	25
20	62	76	79	65	77	76	42	52	54	53	70	69	36	36	34	19	28	24
21	68	82	80	71	72	76	52	65	68	55	79	76	32	32	32	19	31	30
22	66	73	73	59	61	60	57	76	79	64	65	67	35	45	43	31	34	35
23	67	78	74	56	67	69	60	79	80	40	62	60	36	36	34	43	42	34
24	65	66	65	59	70	75	62	80	80	50	69	70	30	31	30	29	31	28
25	55	61	63	61	79	80	67	80	78	56	58	54	30	32	31	14	10	8
26	57	65	68	63	79	78	63	80	79	53	61	68	31	36	34	7	20	23
27	60	75	74	63	78	80	66	80	78	67	62	65	35	37	34	30	34	25
28	62	79	76	64	72	71	60	74	73	50	53	49	34	39	36	22	24	20
29	66	82	75	64	76	79	56	74	55	39	38	35	32	38	35	18	22	24
30	72	83	82	65	82	79	49	49	47	35	46	48	29	43	38	32	36	34
31	69	83	70	68	70	70	....	....	....	48	50	54	....	....	....	31	33	30
AVERAGES	64.0	75.0	73.0	65.3	76.4	74.7	61.3	71.1	70.1	50.5	63.1	62.9	35.0	39.9	37.4	30.2	33.5	31.5

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1920

DATE	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	38	19	23	—16	28	13	73	56	54	36	86	62
2	20	—5	44	17	34	—1	73	56	50	34	87	59
3	14	4	43	21	35	11	62	50	52	35	82	56
4	13	3	30	14	44	20	54	26	53	39	68	48
5	17	1	26	15	44	18	43	29	60	29	63	52
6	28	4	30	21	21	10	37	24	67	34	59	47
7	36	25	32	21	15	11	38	29	69	37	75	46
8	38	31	33	22	30	10	35	30	66	42	75	50
9	33	18	28	19	42	25	38	23	63	40	78	52
10	26	11	35	20	48	40	40	22	55	39	87	64
11	31	12	34	21	49	42	43	34	55	38	86	61
12	30	17	41	10	61	43	50	39	59	40	82	64
13	39	14	40	28	56	20	51	42	59	42	78	58
14	24	9	42	24	31	10	49	32	57	40	86	62
15	11	2	42	8	42	14	55	44	59	40	84	58
16	10	—9	12	—3	58	30	54	40	69	33	74	60
17	24	6	41	3	56	29	55	48	72	38	64	53
18	16	6	30	12	35	24	59	34	76	46	58	51
19	13	—2	20	3	36	29	60	36	85	59	72	44
20	18	—4	26	8	36	31	67	31	77	50	72	60
21	32	12	30	6	40	24	68	51	75	56	72	52
22	14	—2	34	20	56	38	64	52	71	50	71	54
23	25	9	32	8	68	54	68	41	75	52	75	54
24	26	12	32	18	69	36	56	36	72	53	76	58
25	15	5	30	16	71	63	50	23	74	52	77	59
26	25	—10	25	7	73	54	59	29	80	54	83	64
27	41	19	8	1	56	36	58	30	85	60	89	51
28	37	10	25	5	60	37	56	40	82	52	91	64
29	21	0	24	20	62	50	54	36	70	50	94	70
30	37	19	......	......	59	44	55	31	78	41	85	69
31	19	—16	......	......	71	56	......	......	84	56	......	......
AVERAGES	24.8	7.1	37.4	12.7	47.9	30.0	54.1	36.4	67.8	44.0	77.6	56.7

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1920 (*concluded*)

DATE	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	84	56	73	51	80	56	52	41	54	44	44	37
2	78	51	65	53	71	45	57	40	64	40	43	33
3	85	62	74	47	74	51	71	39	58	41	42	26
4	74	56	80	50	79	44	69	52	50	40	54	39
5	80	53	82	58	77	49	70	40	54	46	52	36
6	83	49	82	62	75	59	59	41	50	34	47	31
7	86	66	87	66	73	57	68	36	47	33	36	28
8	79	60	90	61	76	57	75	42	56	40	34	22
9	78	60	90	66	78	51	77	41	60	40	31	20
10	81	63	86	66	76	61	78	52	58	34	36	21
11	80	57	83	62	78	53	70	54	46	33	35	31
12	82	62	86	62	85	59	73	58	40	22	44	30
13	90	70	82	63	83	57	75	47	33	20	50	33
14	85	69	85	66	72	50	79	49	43	27	55	42
15	82	62	84	64	76	45	81	54	39	30	47	32
16	79	47	81	65	77	56	79	52	36	29	35	29
17	78	49	83	66	71	46	66	55	36	30	35	24
18	77	63	79	63	77	51	71	51	42	32	35	25
19	75	61	81	58	74	40	70	50	44	33	33	22
20	80	58	80	59	58	37	77	50	39	34	28	17
21	85	59	81	63	70	46	81	53	35	29	33	18
22	82	62	76	55	83	55	77	60	46	32	37	29
23	80	59	70	51	84	57	68	39	44	31	50	33
24	74	63	78	50	84	56	74	48	34	29	36	28
25	70	49	82	57	83	64	70	53	35	28	31	8
26	70	50	83	55	83	60	72	51	38	30	25	—2
27	78	52	83	54	83	59	71	60	39	33	35	23
28	81	53	81	57	78	59	65	48	42	32	36	18
29	84	62	80	60	76	54	49	38	40	30	26	14
30	85	67	86	63	55	46	50	34	45	28	38	24
31	86	65	81	56	......	......	60	46	......	......	39	29
AVERAGES	80.3	55.3	81.0	59.0	76.8	52.6	69.4	47.5	44.5	32.8	38.8	25.8

SUMMARY OF AVERAGES OF MAXIMUM, MINIMUM, AND STANDARD AIR THERMOMETERS FOR 1920

READING	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Maximum	24.8	37.4	47.9	54.1	67.8	77.6	80.3	81.0	76.3	69.4	44.5	38.8
Minimum	7.1	12.7	30.0	36.4	44.0	56.7	55.3	59.0	52.6	47.5	32.8	25.8
Standard, 7 A. M.	14.1	18.1	30.0	38.0	50.0	61.7	64.0	65.3	61.3	50.5	35.0	30.2
Standard, 12 M.	17.8	24.6	39.7	46.6	62.0	72.8	75.0	76.4	71.1	63.1	39.9	33.5
Standard, 5 P. M.	15.0	23.7	39.9	46.6	61.5	71.3	73.0	74.7	70.1	62.9	37.4	31.5

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1920, INCLUSIVE

(Highest and Lowest Record for Each Month in Heavy Type)

Year	January				February				March				April			
	Max.		Min.		Max.		Min.		Max.		Min.		Max.		Min.	
	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.
1883	18	44.	11	—9.	17	48.	24	—2.	19	61.	9	2.	16	75.	1	19.
1884	14	42.	26	—13.	7	55.	29	—3.	30	54.	1	—4.	28	74.	1	23.
1885	1	61.	29	—6.	10	38.	11	—11.5	28	48.	13	—11.	24	84.5	10	20.5
1886	5	52.5	13	—18.7	9	50.	27	—11.	16	58.	2	—2.5	24	80.5	4	22.
1887	24	50.7	19	—8.	9	54.2	27	—4.	3	51.7	1 & 5	8.7	11	75.7	1	17.2
1888	2	43.2	23	—6.	21	49.	10	—7.	28	57.	13	0.	29	82.5	8	19.
1889	18	55.	20	5.	23	42.	4 & 24	—7.	28	61.8	30	18.5	20	84.	1	26.
1890	6	67.	29	9.	5	64.5	11 & 21	9.5	13	62.	8	2.	13	78.8	1 & 19	23.
1891	3	46.	17	4.	26	56.8	15	2.5	12	57.	2	4.5	28	81.4	7	21.
1892	3	48.	10	—5.	15	44.	6	2.8	27	52.2	4	6.	6	78.	17	25.5
1893	29	46.	11	—6.	15	47.4	5	—1.	24	54.	5	9.	13	75.3	26.2	25.
1894	5	59.	13	11.	20	47.6	27	—8.5	18	73.	26	15.	21	71.3	2	20.
1895*	7	45.	19	4.	25	46.	8	—14.	25	52.	5 & 16	12.	30	80.	3	28.
1896	30	44.	6	—16.5	29	49.	17	—21.	31	56.5	24	—2.	17	87.	4 & 5	19.
1897	5	58.	20	—3.5	18	49.5	1 & 27	5.5	21	64.	1	—1.	26	82.	20	19.
1898	13	57.	30 & 31	—4.	12	56.5	2 & 3	—2.	11	†65.	2	17.5	14 & 18	69.	5	18.
1899	5	59.	12	—4.	21	52.5	11	—8.	13	63.	21	13.	30	82.	3	28.
1900	23	56.	1	2.	14	57.	27	0.	10	46.	12	—3.	30	‡73.5	9	22.
1901	16	48.	20	—2.	16	36.	24	—2.5	24	67.	6	—1.	28	78.	12	28.
1902	3	44.	28	2.	28	52.	6	—3.	12	66.5	19	14.	22	87.	5	25.
1903	3	48.	9	—2.	28	62.5	18	—4.	19	78.5	1 & 2	19.	30	86.	5	31.
1904	23	48.	19	—14.	7	58.	16	18.	26	58.	4	8.	24	67.5	14	16.
1905	1	49.	26	—2.	20	45.	5 & 14	—6.	20	82.	5	1.	27 & 28	75.	16	23.
1906	21	71.	9	4.	24	64.	6 & 7	—7.	27	51.	25	2.	19	74.	2	25.
1907	6	53.	24	—18.	2	47.	12	—4.	29	83.	7	—1.	29	73.	2	19.
1908	22	45.	31	—9.	15	53.	2 & 5	—14.	28	73.	1	8.	27	78.	4	18.
1909	24	64.	19	—7.	5	52.	1	—1.	10	52.	5	5.	19	75.	11	12.
1910	2 & 22	45.	5	—8.	16	29.	7	—3.	24	82.	14 & 18	17.	4	84.	7	27.
1911	27 & 30	48.	5	—1.	17	52.	22	4.	27	60.	16	—1.	29	80.	3	18.
1912	18	44.	14	—12.	24	48.	10	—10.	31	62.	4	—1.	6	78.	4	19.
1913	17	57.	13	8.	20	65.	10	—10.	14 & 15	69.	7 & 8	1.	24	84.	20	24.
1914	29	51.	13 & 14	—9.	3	52.	13 & 24	—14.	26	65.	12	7.	19	82.	9 & 13	22.
1915	7	46.	30	—3.	21 & 23	53.	10	10.	25	50.	1	11.	25 & 26	88.	5	23.
1916	27	61.	17	—3.	1	47.	15	—8.	31	58.	18	—3.	21	73.	8	26.
1917	6	47.	11 & 12	1.	26	55.	13	—8.	31	68.	6 & 29	11.	22	80.	11 & 18	23.
1918	12	40.	2	—10.	20	55.	5	—11.	20	74.	11	7.	1 & 29	73.	9	23.
1919	21	5.	12	—1.	28	54.	11	8.	26	69.	7	3.	23	71.	1	10.
1920	13	39.	31	—16.	2	44.	1	—16.	26	73.	2	—1.	1 & 2	73.	10	22.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.
† Maximum for first eleven days only. Record incomplete.
‡ Thermometers broken. Record not taken from April 19th to 24th, inclusive.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1920, INCLUSIVE (*Continued*)

(Highest and Lowest Record for Each Month in Heavy Type)

Year	May Max. Date	May Max. Temp.	May Min. Date	May Min. Temp.	June Max. Date	June Max. Temp.	June Min. Date	June Min. Temp.	July Max. Date	July Max. Temp.	July Min. Date	July Min. Temp.	August Max. Date	August Max. Temp.	August Min. Date	August Min. Temp.
1883													23	92.		46
1884													20	95.		44.
1885													1	89.		45.
1886													30	91.		47.7
1887													3	88.		46.
1888													9	92		48.3
1889													31	96.		50.3
1890													4	96.		46.
1891													12	92		46.5
1892													10	95.		49.
1893													11	94		49.
1894													25	93.		45.3
1895*													11	88.		44.
1896													6 & 7	96.		44.
1897													15	87.		46.
1898													24	90.		47.
1899													20	97.		44.5
1900													11	97.		51.
1901																
													22	90.		52.
1902													31	90.		47.
1903													13	88.		46.
1904																
													25	89.		45.
1905													10	93.		41.
1906																
													5	98.		47.
1907																
													12	96.		41.6
1908																
													4	95.		46.
1909													8	96.		42.
1910	20	79.	16	31.5	22	89.9	4	38.	9	96.5	5	50.	3 & 16	90.		44.
1911	22	97.	3	27.	11	90.5	17	46.	5.	105.	25–26 & 27	50.	8	94.		47.
1912	24	88.	14	34.	1	89.	8	40.	8 & 10	95.	1	41.	14	92.		44.
1913	4	91.	11	30.	20	92.	9	37.	1 & 4	96.	13	50.	17	98.		44.

1914	26 & 27	90.	1	34.	24 & 25	90.	20	30.	11	93.	4	50.	9	94.	26	47.
1915	23	77.	3 & 4 10 & 27	34.	18 & 19	86.	4 & 9	41.	31	90.	22 & 23	49.	1	89.	27	43.
1916	24 & 28	82.	10 & 19	37.	27	82.	1	41.	30	96.	1	49.	22	101.	2 & 29	46.
1917	19	82.	4	32.	13 & 19 & 20	88.	16 & 17	46.	31	96.	4	50.	1 & 2	96.	31	47.
1918	6–18 & 31	84.	5	35.	1 & 2	90.	20	38.	21–22 & 28	95.	3	48.	13 & 14	98.	18 & 19	45.
1919	31	86.	6	32.	3	96.	29	42.	4 & 5	95.	11	49.	7 & 8	92.	10	45.
1920	19 & 27	85.	5	29.	29	94.	19	44.	13	90.	16	47.	8 & 9	90.	3	47.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1920, INCLUSIVE (*Concluded*).

(Highest and Lowest Record for Each Month in Heavy Type.)

YEAR	SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER			
													MAX.		MIN.	
													Date	Temp.	Date	Temp.
1883													9 & 14	56.	23	—7.5
1884													31	55.5	20	—15.5
1885													24	53	9	4.
1886													11&25	46.	6	—6.
1887													12	54.7	2	—3.
1888													27	53.	23	4.
1889													25	60.5	4 & 5	8.
1890													1	46.2	20	3.
1891													5	57.7	18	7.
1892													9	49.2	27	—3.7
1893													26	62.	14	1.5
1894													17	59.	29	—0.2
1895*													20&21	62.	13	—2.
1896													14	58.	28	2.
1897													12	61.5	24	2.
1898													31	54.	14	3.
1899													13	60.	31	—1.
1900													4	55.	10&14	4.
1901													14	62.	16	—1.
1902													3	52.	9	—5.
1903													3	46.	19	—4.
1904													23	53.	16	—2.
1905													29	52.5	15	1.
1906													6	52.	8	—1.
1907													30	57.	22	13.5
1908													1	64.	23	3.
1909													6	45.	30	1.
1910													29	41.	31	—2.5
1911													9	67.9	4 & 30	13.
1912													6	65.	9 & 12	12.
1913													7	56.	28	6.
1914													2	64.	26&27	—6.
1915													25	45.	31	4.
1916													5	62.	30	4.
1917													24	44.	30	—18.
1918													14	55.	7	9
1919	7	92.	27	37.	19	80.	3 & 12	30.	1	71.	28	31.	13	50.	13	—6
1920	12	85.	20	37.	15 & 21	81	30	34.	2	64.	12	22.	14	55.	26	—9

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.
† Thermometer broken on the 27th, 28th, and 29th of October.

YEARLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1920, INCLUSIVE

(Highest and Lowest Record for THE TIME in Heavy Type)

YEAR	MAXIMUM FOR EACH YEAR		MINIMUM FOR EACH YEAR	
	Date	Temp.	Date	Temp.
1883	Aug. 23	92.	Jan. 11	— 9.
1884	Aug. 20	95.	Dec. 20	—15.5
1885	July 18	90.5	Feb. 11	—11.5
1886	July 7	95.	Jan. 13	—18.7
1887	July 3	95.5	Jan. 19	— 8.
1888	June 23	94.1	Feb. 10	— 7.
1889	May 18	91.8	Feb. 4 and 24	— 7.
1890	Aug. 4	96.2	Mar. 8	2.
1891	June 16	95.	Feb. 15	2.5
1892	July 29	96.3	Jan. 10	— 5.
1893	July 26	95.5	Jan. 11	— 6.
1894	July 21	97.	Feb. 27	— 8.5
1895*	June 3	96.	Feb. 8	—14.
1896	Aug. 6 and 7	96.	Feb. 17	—21.
1897	Sept. 11	98.	Jan. 20	— 3.5
1898	July 4	96.5	Jan. 30 and 31	— 4.
1899	July 4 and Aug. 20	97.5	Feb. 11	— 8.
1900	Aug. 1	97.	Feb. 27	0.
1901	July 1	97.5	Feb. 24	2.0
1902	May 24, July 14 and 27, August 31 and Sept. 1	90.	Dec. 9	— 5.
1903	July 9	94.	Feb. 18 and Dec. 19	— 4.
1904	July 19	93.	Feb. 16	—18.
1905	Aug. 10	93.	Feb. 5 and 14	— 6.
1906	Aug. 5	93.	Feb. 6 and 7	— 7.
1907	Aug. 12	96.5	Jan. 24	—18.
1908	Aug. 4	95.	Jan. 2 and 5	—14.
1909	Aug. 8	98.	Jan. 19	— 7.
1910	July 9	96.5	Jan. 5	— 8.
1911	July 5	105.	Jan. 5	— 1.
1912	Sept. 6	95.	Jan. 14	—12.
1913	Aug. 17	98.	Feb. 10	—10.
1914	Aug. 9	94.	Feb. 13 and 24	—14.
1915	Sept. 14	93.	Jan. 30	— 3.
1916	Aug. 22	101.	Feb. 15	— 8.
1917	July 31, Aug. 1 & 2	96.	Dec. 30	—18.
1918	Aug. 13 & 14	98.	Feb. 5	—11.
1919	June 3	96.	Dec. 18	— 6.
1920	June 29	94.	Jan. 31 and Feb. 1	—16.

* Data from record kept by Mr. Edgar Parker; Station record not available.

MONTHLY AND YEARLY MEANS OF TEMPERATURES SINCE 1883.

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	YEARLY AVER'GES
1883	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5	44.0
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2	46.1
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8	43.3
1886	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22.2	45.5
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6	45.9
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.3	44.6
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.0	60.5	44.0	40.3	35.2	47.2
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4	46.7
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5	47.7
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.2	50.0	35.9	25.2	45.9
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5	45.3
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5	48.6
1895	21.8	16.9	26.9	44.4	59.0	......	......	71.2	61.7	45.4	39.6	31.4	......
1896	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1	48.0
1897	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2	47.6
1898	26.2	26.8	......	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9	......
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.5	38.9	30.0	47.7
1900	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7	48.4
1901	26.1	18.5	32.2	46.5	56.9	68.9	76.6	71.0	64.0	51.4	34.3	27.7	47.9
1902	23.2	22.2	39.5	46.6	56.1	63.2	71.2	67.6	53.6	43.1	46.3	25.7	47.4
1903	25.7	28.1	42.2	45.9	60.4	63.2	70.8	65.5	64.4	52.5	36.2	23.3	48.2
1904	18.9	23.1	30.9	41.4	60.3	67.8	70.0	68.2	61.9	48.4	36.9	22.5	45.9
1905	19.8	18.9	33.1	44.8	57.5	66.4	71.8	68.7	63.7	52.4	37.6	32.0	47.2
1906	32.5	26.1	27.6	46.4	57.5	68.2	71.4	72.8	67.3	51.2	37.9	26.1	48.8
1907	24.9	19.5	38.1	40.2	51.3	64.0	71.2	68.4	64.4	47.9	38.7	31.8	46.7
1908	25.9	21.3	34.6	44.8	59.2	68.8	73.4	68.8	67.0	52.9	40.0	29.2	48.8
1909	27.7	28.6	31.0	44.3	57.9	67.2	69.6	70.0	68.5	47.7	44.5	25.7	48.1
1910	25.1	22.1	42.1	50.1	54.9	65.2	73.1	69.0	63.2	53.1	35.7	21.5	47.9
1911	24.0	26.6	30.9	44.8	64.9	67.5	74.4	70.9	62.8	50.7	36.6	35.1	49.4
1912	15.9	21.6	28.2	45.1	58.9	64.3	73.2	68.6	68.4	53.5	42.5	33.9	47.8
1913	32.7	18.8	36.9	48.3	56.9	66.8	72.1	70.0	61.3	54.0	44.5	33.6	49.7
1914	25.4	17.7	31.7	43.4	60.2	67.3	59.9	70.5	61.4	55.4	39.2	26.0	46.5
1915	26.5	29.6	31.0	52.3	52.6	64.6	69.6	67.8	65.6	52.6	41.1	28.5	48.5
1916	29.0	19.5	27.5	49.5	59.5	61.5	72.5	73.5	66.0	58.0	45.0	33.0	49.5
1917	24.6	20.2	33.8	45.8	49.5	63.9	71.8	70.5	60.1	45.9	35.3	19.5	45.0
1918	14.8	23.4	37.6	45.6	61.9	63.2	70.2	72.2	57.4	53.5	22.1	33.6	46.3
1919	31.0	29.2	35.7	43.6	57.0	71.8	72.0	67.8	64.7	55.4	39.6	23.4	49.3
1920	16.3	21.8	39.0	45.2	56.0	67.2	69.4	70.0	64.5	58.5	38.8	32.3	47.4
MONTHLY AVERAGES	23.6	22.8	30.6	44.8	56.7	64.5	68.9	69.1	62.4	51.0	38.0	28.3	46.7

PRECIPITATION BY RAINFALL ONLY BY MONTHS SINCE 1882.

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	TOTAL
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1882	......	......	......	......	......	3.69	2.42	2.37	1.25	0.62	1.22	0.55	......
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.79	3.48	1.24	27.87
1887	0.18	2.97	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	2.88	0.99+	4.02	2.73	3.47	2.02	1.24	20.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	4.26	1.07	4.34	5.81	4.54	2.40	......	36.88
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	2.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	1.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	2.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.04	3.59	0.43	0.47	29.36
1895	0.96	......	0.29	1.36	2.88	......	......	2.66	0.94	0.72	2.31	2.49	......
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.37	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73
1901	0.72	......	2.19	4.43	3.80	2.07	3.97	5.52	2.46	1.35	2.09	3.37	31.97
1902	0.86	0.66	1.94	1.92	2.84	4.33	5.29	2.41	2.88	2.32	0.74	0.74	26.89
1903	1.81	1.11	5.62	2.60	0.23	7.77	4.86	7.21	1.30	4.19	1.63	0.38	38.69
1904	0.80	1.03	2.41	1.67	4.04	3.37	5.73	2.56	3.26	2.06	0.26	1.42	28.61
1905	0.40	0.27	1.09	2.05	2.01	8.78	3.59	5.44	1.90	3.69	1.82	1.84	32.38
1906	1.46	0.53	1.60	2.08	4.24	5.31	2.37	3.68	2.16	3.56	1.40	1.54	29.93
1907	1.89	0.03	1.14	2.42	1.82	2.34	2.86	1.35	2.73	2.48	2.78	1.89	24.73
1908	0.68	1.12	1.24	3.28	3.57	1.96	4.72	1.79	1.66	2.73	0.88	0.43	24.06
1909	0.94	1.68	1.35	3.20	2.83	2.17	2.04	2.21	2.22	1.18	0.56	0.49	20.87
1910	0.87	0.53	0.28	4.56	3.45	1.55	2.39	5.47	3.29	1.73	0.62	0.38	25.12
1911	0.91	0.24	1.07	3.24	1.36	2.51	4.49	3.36	3.21	2.37	1.41	2.08	26.25
1912	0.20	0.95	1.92	3.41	7.27	2.09	4.85	2.21	5.89	1.42	1.48	1.13	32.82
1913	3.88	0.11	4.64	3.40	2.68	3.24	2.03	1.65	2.64	4.03	2.41	0.77	31.48
1914	0.98	0.15	1.28	3.10	4.00	2.69	2.18	6.05	1.62	1.55	1.08	1.13	25.81
1915	2.34	1.77	0.30	0.64	2.41	2.57	2.44	5.90	1.78	4.44	1.93	1.23	27.75
1916	2.69	1.05	0.50	3.40	5.69	5.83	1.78	3.47	2.15	1.41	1.83	1.49	31.29
1917	0.72	0.95	1.57	2.92	3.74	7.07	3.16	1.99	1.82	4.37	0.36	0.46	29.13
1918	0.19	0.91	2.09	2.08	4.10	3.38	4.21	2.25	3.60	3.39	2.25	1.78	30.23
1919	0.38	0.53	2.85	4.04	6.52	2.47	3.52	3.58	1.00	3.73	2.47	0.76	31.85
1920	0.15	0.00	1.13	1.68	0.75	3.25	5.04	5.27	3.98	1.41	3.69	2.21	28.56
MONTHLY AVERAGES	1.19	1.01	1.54	2.34	3.07	3.47	3.50	3.42	2.52	2.59	1.83	1.24	27.72

TOTAL PRECIPITATION, RAINFALL AND SNOW REDUCED TO EQUIVALENT RAINFALL, 1918 TO 1920

YEAR	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1918	1.74	1.59	2.82	2.38	4.10	3.38	4.21	2.25	3.60	3.39	2.25	2.68	34.39
1910	0.78	0.93	4.15	4.34	6.52	2.47	3.52	3.58	1.00	3.73	2.67	1.91	35.60
1920	3.10	2.40	2.33	2.64	0.75	3.25	5.04	5.27	3.98	1.48	4.29	2.71	37.24
MONTHLY AVERAGES	1.87	1.64	3.10	3.12	3.79	3.03	4.25	3.70	2.86	2.86	3.07	2.43	35.72

INDEX

INDEX TO LEGISLATIVE DOCUMENTS, 1921